NEUMANN, C
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THE

CHEMICAL WORKS

OF

CASPAR NEUMANN, M. D.

THE

CHEMICAL WORKS

OF

CASPAR NEUMANN, M. D.

Profeſſor of CHEMISTRY at BERLIN, F. R. S. &c.

ABRIDGED and METHODIZED;

WITH

LARGE ADDITIONS,

CONTAINING THE LATER

DISCOVERIES and IMPROVEMENTS

MADE IN

CHEMISTRY,

And the ARTS DEPENDING THEREON.

By WILLIAM LEWIS, M. B. F. R. S.

The SECOND EDITION.

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MDCCLXXIII.

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PREFACE.

THE editor of *Neumann*'s chemical lectures publiſhed at *Zullichau*, has prefixed to them a minute detail of the author's life; in which we are informed of his being early received into the favour of the King of *Pruſſia*; of his travelling at his majeſty's expence, to get acquainted with the chemical arts and buſineſſes carried on in the different parts of *Europe*; of his being entertained, in this progreſs, by men of the moſt diſtinguiſhed abilities in the ſeveral branches of natural knowledge; of his advancement to the public Profeſſorſhip, the direction of the royal elaboratory, and apotheca at *Berlin*. How much he availed himſelf of theſe uncommon advantages, is obvious from his own writings.

THE works publiſhed by *Neumann* himſelf conſiſt chiefly of diſſertations on particular ſubjects; ſome in *Latin*, and inſerted in the tranſactions of different ſocieties and academies, of which he was a member; others in the *German* language, and printed ſeparately.

In the Philoſophical Tranſactions of the Royal Society of *London*;

1. *Diſquiſitio de Camphora*, N° 399.
2. *De experimento probandi ſpiritum vini Gallici, perquam uſitato, ſed revera falſo & fallaci*, N° 391.
3. *De ſalibus alkalino-fixis*, N° 392.
4. *De camphora thymi*, N° 431.
5. *De ambragryſea*, N° 433.

In the *Ephemerides*, or *Acta phyſico-medica, Academiæ Cæſareæ naturæ curioſorum*.

1. *De oleo diſtillato formicarum æthereo*, Vol. ii.
2. *De albumine ovi ſuccino ſimili*, Vol. v.

In the *Miſcellanea Berolinenſia*;

1. *Meditationes in binas obſervationes de aqua per putrefactionem rubra, vulgo pro tali in ſanguinem verſa habita*, Tom. iii.
2. *Succincta relatio ex actis Pomeranicis de prodigio ſanguinis in palude viſo*, ibid.
3. *De prodigio ſanguinis ex Pomerania nunciato*, ibid.
4. *Diſquiſitio de camphora*, ibid.
5. *De experimento probandi ſpiritum vini Gallicum*, &c. ibid.
6. *De ſpiritu urinoſo cauſtico*, ibid.
7. *Demonſtratio ſyrupum violarum ad probanda liquida non ſufficere*, Tom. iv.
8. *Examen correctionis olei raparum*, ibid.
9. *De vi cauſtica & converſione ſalium alkalino-fixorum aeri expoſitorum in ſalia neutra*, Tom. v.

In the *Commercium literarium phyſicho-technicum medicum Norimbergenſe*:

Judicium & experimenta circa tincturas coralliorum, Ann. 1735, hebd. 1747 & 1748.

Publiſhed ſeparately in *German*:

1. *Einpropfung der pocken*, Berlin, 1727.
2. *De ſalibus alkalino-fixis & camphora*, Berlin, 1727.
3. *De ſuccino, opio, caryophyllis aromaticis, & caſtoreo*, Berlin, 1730.
4. *Vom ſalpeter, ſchwefel, ſpieſsglaſs, und eiſen*, Berlin, 1732.
5. *Vom thee, coffee, bier, und wein*, Leipſic, 1735.
6. *Diſquiſitio de ambra gryſea*, Dreſden, 1736.
7. *Vom gemeinen ſaltz, weinſtein, ſalmiac, und der amieſe*, Leipſic, 1737.

The foregoing are all the writings of *Neuman* publiſhed in his life-time. Since his death two copies of his chemical lectures have appeared.

The firſt conſiſts of notes taken down by one of his pupils, intermixed with a number of incoherent compilations from different authors. This is intitled *Herr D. Caſper Neumann*'s, *geweſenen königl. Preuſſiſchen Hofraths und profeſſoris publici chemiæ practicæ, &c. Prelectiones chemicæ, ſeu chemia medico-pharmaceutica experimentalis & rationalis — herauſgegeben von D. Johann Chriſtian Zimmermann medicinæ practico in Schneeberg*. Berlin, 1740, 1740, 2 vol. quarto—pages 1872, excluſive of prefaces and index.—Of this copy a ſecond edition has been publiſhed, not materially different, ſo far as I have obſerved, from the former, though *Neumann*'s name is omitted in the title page, which in this new edition is as follows: *Allgemeine grundſatze der theoretiſch-practiſchen chemie, das iſt, gründlicher und vollſtändiger unterricht der chemie; in welchem nicht nur überhaupt eine gründliche anleitung zu allen theilen der chemie, ſondern auch die—operationes und producta—mit demonſtrationibus und experimentis—gelehret werden; nebſt beygefügten mediciniſchen, chirurgiſchen, oeconomiſchen, metallurgiſchen,* &c. *gebrauch und anwendung. Herauſgegeben von D. Johann Chriſtian Zimmermann.* Dreſden, 1755—2 vol. quarto—pages 1604.

The other copy is printed by the bookſellers of the orphan hoſpital of *Zullichau* (the city of *Neumann*'s birth) and ſaid to be taken from the original papers in the Author's own handwriting. This alſo has had two impreſſions; one of which is an abridgement of the other, from ſeven Volumes in Quarto into two, from upwards of 7000 pages into 2560, under the following title: *D. Caſper Neumaun*'s, *ehemahligen königl, Preuſſiſchen Hofraths, profeſſoris der chemie, &c. Chymia medica, dogmatico-experimentalis, das iſt, gründliche und mit experimenten erweiſene mediciniſchen chymie. Zullichau,* 1756.

The editor of this abridgment obſerves, that *Neumann*'s writings are extremely voluminous, and that therefore he has endeavoured to reduce them, in ſuch a manner as not to mutulate the ſenſe, but to give the whole of the proceſſes, experiments, and obſervations, in the Author's own words. So ſcrupulouſly has this abridger fulfilled his taſk in this reſpect, that he has in general not ventured to contract *Neumann's* diffuſe manner of writing, or rather ſpeaking to his audience. Much of the work is ſtill taken up in a minute account of medicinal preparations, many of which are not uſed; in the formal refutation of theories and opinions not now received; in narratives and diſcuſſions often foreign to the ſubject, and frequently frivolous in themſelves. An account of the apparatus of the tea-table, and the manner of making tea, fills a quarto page and a half of this abridgement.

The general arrangement of the materials, excluſive of the minute and trifling ſubdiviſions, is likewiſe very exceptionable. Thus the chemical products or preparations *, which make the

---

* The general diſtribution of the chemical preparations is as follows.

Part I. Of liquid preparations.

Sect. I. Of waters.

Chap. 1. Of ſimple diſtilled waters.
Chap. 2. Of compound diſtilled waters.
Chap. 3. Of waters not diſtilled.

Sect. II. Of ſpirits.

Claſs I. Of inflammable ſpirits.

Chap. 1. Of ſimple inflammable ſpirits.
Chap. 2. Of ſpirits prepared by ſolution.
Chap. 3. Of ſimple diſtilled inflammable ſpirits.
Chap. 4. Of compound diſtilled inflammable ſpirits.

Claſs

the two firſt parts, being divided into liquid and ſolid; volatile ſpirits are placed in the one part, and the ſalts in the other; though they ought

Claſs II. Of ſaline ſpirits.

Chap. 1. Of urinous ſaline ſpirits.
Chap. 2. Of vegetable acid ſpirits.
Chap. 3. Of ſimple mineral acid ſpirits.
Chap. 4. Of compound mineral acid ſpirits.

Claſs III. Of oily ſaline ſpirits.

Chap. 1. Of oily alkaline ſaline ſpirits.
Chap. 2. Of oily acid ſaline ſpirits.
Chap. 3. Of compound oily ſaline ſpirits.

Sect. III. Of tinctures.

Claſs I. Of acid tinctures.

Chap. 1. Of watery acid tinctures.
Chap. 2. Of ſpirituous acid tinctures.

Claſs II. Of alkaline tinctures.

Chap. 1. Of tinctures made with fixt alkali.
Chap. 2. Of tinctures made with volatile alkali.

Claſs III. Of neutral tinctures.

Chap. 1. Of thin neutral tinctures.
Chap. 2. Of thick neutral tinctures.

Claſs IV. Of alkaline oily tinctures.

Chap. 1. Of ſimple alkaline oily tinctures.
Chap. 2. Of compound alkaline oily tinctures.

Claſs V. Of oily or reſinous tinctures.

Sect. IV. Of eſſences.

Sect. V. Of elixirs.

Sect. VI. Of ſaline ſolutions.

Sect. VII. Of oils.

Claſs I. Of expreſſed oils.

Chap. 1. Of ſimple expreſſed oils.
Chap. 2. Of boiled oils.

ought naturally to come together, the ſpirit ing no more than a ſolution of the ſalt in water. The chemical ſubjects (which compoſe the

other

Claſs II. Of diſtilled oils.

Chap. 1. Of eſſential oils.
Chap. 2. Of empyreumatic oils.

Sect. VIII. Of balſams.

Claſs I. Of natural balſams.

Claſs II. Of artificial balſams.

Chap. 1. Of ſpirituous balſams.
Chap. 2. Of oily balſams.
Chap. 3. Of ſalve-balſams.
Chap. 4. Of improper balſams.

Sect. IX. Of extracts.

Claſs I. Of ſimple extracts.

Chap. 1. Of extracts called ſuch.
Chap. 2. Of extracts not called ſuch.
Chap. 3. Of ſuch as ought not to be ſo called.

Claſs II. Of compound extracts.

Chap. 1. Of pure compound extracts.
Chap. 2. Of impure compound extracts.

Part II. Of ſolid preparations.

Sect. I. Of ſalts.

Claſs I. Of alkaline ſalts.

Chap. 1. Of volatile alkaline ſalts.
Chap. 2. Of fixt alkaline ſalts.

Claſs II. Of dry acid ſalts.

Chap. 1. Of volatile dry acid ſalts.
Chap. 2. Of fixt dry acid ſalts.

Claſs III. Of neutral ſalts.

Diviſion I. Of ſaturated neutral ſalts.

Chap. 1. Of ſaturated volatile neutral ſalts.
Subdiviſion 1. . . . . pure.
Subdiviſion 2. . . . . more earthy.

Chap.

other three parts, under the heads of vegetables, animals, and minerals) are ranged for the moſt part alphabetically; each article being conſidered

Chap. 2. Of ſaturated fixt neutral ſalts.
  Subdiviſion I. Pure fixt neutral ſalts, in the humid way.
    1. . . . . vegetable.
    2. . . . . mineral.
      1. . . . with the acid of common ſalt.
      2. . . . with the acid of nitre.
      3. . . . with the acid of vitriol.
  Subiviſion II. more earthy fixt neutral ſalts.
  Subdiviſion III. Fixt neutral ſalts in the dry way.
    1. . . . pure.
    2. . . . more earthy.
  Diviſion II. Of falſe neutral ſalts.
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Chap. 2. . . . impure.
  Claſs IV. Metallic ſalts.
  Diviſion I. . . . volatile.
  Diviſion II. . . . more fixt.
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Chap. 2. . . . with the nitrous acid.
Chap. 3. . . . with the vitriolic acid.
Chap. 4. . . . with different acids.

Sect. II. Of earthy ſaline bodies.

Sect. III. Of ſulphureous bodies.

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Sect. IV. Of reguli.

Chap. 1. Of ſimple reguli.
Chap. 2. Of compound reguli.

Sect. V. Of magiſteries.

  Claſs I. Of earthy magiſteries.
Chap. 1. Thoſe made from vegetables.
Chap. 2. . . . from animals.
Chap. 3. . . . from minerals.

ſidered as one ſeparate whole, and not as making part of a larger ſtructure. So ſcrupulouſly is the order of *Neumann*'s lectures preſerved, that where he deferred a ſubject to a future meeting, on account of his experiments upon it not having been finiſhed at the time when he ought to have ſpoken of it, the ſubject continues miſplaced in all the editions.

Neumann's lectures are a valuable magazine of chemical knowledge. The Author, biaſſed by no theory, and attached to no opinions, has enquired by experiment into the properties and uſes of the moſt conſiderable natural and artificial productions, and the preparation of the principal commodities which depend on chemiſtry;

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Chap. 2. . . . from imperfect and perfect metals.
Chap. 3. . . . from perfect metals.
Claſs III. Of ſulphureous magiſteries.
Claſs IV. Of reſinous magiſteries.
Claſs V. Of compound magiſteries.
Claſs VI. Of falſe magiſteries.

Sect. VI. Of calces and croci.
Claſs I. Of animal calces.
Claſs II. Of mineral calces.
Chap. 1. Of ſimple mineral calces.
Chap. 2. Of compound mineral calces.

Sect. VII. Of glaſſes.

Part III. contains the vegetable, Part IV. the animal, and Part V. the mineral ſubſtances, examined by the Author. It is needleſs to inſert the alphabetic catalogues of them, as the table of contents of the preſent work conſiſts of the ſame articles, ranged in a more ſcientific method, a method which *Neumann* himſelf has in different parts of his writings pointed out.

miſtry; and ſeems to have candidly, and without reſerve, communicated all he diſcovered.

THE merit of this work, ſo much celebrated in *Germany*, and ſo little known here, engaged me to reviſe and abridge an *Engliſh* tranſlation, and to make ſuch additions as appeared neceſſary for ſupplying the deficiencies of the Author.

In regard to the original, the *Zullichau* edition has been followed; the abrupt tranſitions and mutulated ſentences of the other ſhewing it to be of no authority. In the contraction, I found it neceſſary to proceed much further than the abridger of *Zullichau* has done, and to take ſome liberties not perhaps very common in performances of this kind. It ſeemed requiſite, not ſo much to retrench the trivial and redundant, as to extract and digeſt the uſeful matter. Accordingly I have ventured to new mould the whole fabrick; and hope it will appear, that all the valuable meterials, ſcattered through *Neumann*'s, writings are collected and diſpoſed with propriety.

I have added by way of notes, the later diſcoveries and improvements made in chemiſtry and the arts depending thereon. Much of this part of the work is taken from the writings of others and not a little from the diaries of my own elaboratory.

THE index is to be conſidered not barely as a table of references, but as a ſummary of the moſt conſiderable facts, which are there repreſented commonly in a new light. Several facts are mentioned in the index which though deducible by analogy from the experiments in the pages referred to, could not on that foundation alone be looked upon as certain. There are even ſome facts which have no reference at all, and which are not mentioned in the book. Thus Acacia, an inſpiſſated vegetable juice, pepared in *Egypt*, rarely met with among us, uſed in medicine as a mild aſtringent, is omitted by the author; and ſuch an article did not ſeem to be of importance enough to be introduced: but on taking a review of the *aſtringency* of vegetables in the index, the light in which this quality appeared there made Acacia worthy of notice; for as among the vegetables examined by the author, the aſtringency of ſome diſſolves both in water and in ſpirit, and that of others in ſpirit only; Acacia is an inſtance of a third kind of aſtringent matter, diſſolving in water only.

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PART I.

CHEMICAL HISTORY OF THE MINERAL KINGDOM.

SECTION I.

EARTHS *and* STONES.

EARTHS

Common diviſion of Earths and Stones, ſuperficial.

EARTHS and Stones are conſidered by naturaliſts as two diſtinct claſſes of bodies: and each of them arranged, from certain obvious appearances, as colour, conſiſtence, external figure, texture, &c. into numerous ſubdiviſions. A chemical examination has diſcovered, that many of theſe apparently very different bodies are, in their eſſential properties, the ſame; and that many of thoſe, which are apparently ſimilar, are eſſentially very different. Thus the ſofteſt Chalk, the hardeſt Marbles, the moſt pellucid Spars, are found to be at bottom one and the ſame Earth: fire reduces them all into Quicklime; Acids diſſolve, and form with them indiſtinguiſhable compounds. And, on the other hand, the Talcs and Gypſums, though ſome of them are externally ſo much alike as to have often been confounded with one another, and called by the ſame name, conſiſt of Earths entirely diſtinct: one reſiſts the moſt vehement fires, whilſt the other, in a very moderate heat, ſeems to liquefy and boil, and changes into the ſubſtance called Plaſter-of-Paris: the latter, burnt in contact with the fuel, diſſolves readily in Acids; whilſt the former, treated in the ſame manner, continues to reſiſt every kind of humid *Menſtruum.*

Stahl, diſregarding ſuperficial and ineſſential characters, formed a diſtribution of Earths and Stones from their chemical properties. He divides them all into two claſſes, Vitreſcible and Calcareous; the firſt comprehending thoſe which have a greater or leſs degree of tranſparency, and are diſpoſed to vitrify in the fire; the other, ſuch as are opake, become brittle or hard in the fire, and reſiſt vitrification. This arrangement, though an uſeful one, is in ſeveral reſpects exceptionable, and requires further diſtinctions and limitations.

Chemical diſtribution of them.

" Experiments have ſhewn, that there are four kinds of Mineral Earths, diſtinct from one another, the Cryſtalline, Calcareous, Argillaceous and Talky; to which may be added a fifth ſort of earthy concrete, the Gypſeous. All the earthy and ſtony bodies of the Mineral Kingdom, that have been chemically examined, are found to conſiſt of theſe, not often in their ſeparate or pure ſtate, but for the moſt part variouſly blended together, and combined with metallic or other heterogeneous matters.

Each of the ſimple Earths, and the gypſeous concrete, ſuſtains, by itſelf, the moſt vehement degrees of Fire that art has hitherto been able to excite, without ſhewing any diſpoſition to melt or ſoften: two or more of them, mixed together, oftentimes melt in a moderate fire, and form a truly vitreous compound. This remarkable property is a proof of the intrinſic diſſimilarity of the Earths; for we cannot ſuppoſe that an unfuſible ſubſtance would be brought into fuſion by the bare addition of its like. It follows alſo, that fuſibility, though uſually looked upon as a character of one particular ſpecies of ſimple Earth, is really a character of compoſitions of Earths, and belongs equally to a great variety of combinations of them——The ſimple Earths are brought into fuſion by the addition of certain Salts and metallic calces: and ſuch mixtures of Earths, as do not melt by themſelves, melt with a leſs proportion of theſe fluxes than the ingredients ſeparately would require. The different Earths differ remarkably in their relation to theſe bodies; ſome intirely reſiſting thoſe which are moſt powerful fluxes for others——It may be proper to obſerve, that the reſult of the fuſion of Earths, by whatever means effected, is conſtantly a vitreous matter. Some metallic calces and glaſſes would not eaſily be diſtinguiſhable from thoſe of Earths, if the metallic ones were not revivable by inflammable fluxes into their proper metallic ſtate."

EARTHS

CLASS I. CRYSTALLINE STONES.

Stony bodies of great hardneſs, capable of ſtriking fire with ſteel;—by vehement heat and extinction in water, becoming brittle, friable, or powdery;—not acted upon in the leaſt by Acids, either in their natural ſtate or when calcined.

I. FLINT.

FLINT.

Natural Hiſtory.

THE Flint is a ſemitranſparent ſtone, generally covered with an opake white cruſt. Its colour varies, from a pale browniſh grey, to a dark browniſh black: its texture is always ſmooth and uniform; its figure irregular. Thoſe found in the beds of rivers, or thrown out upon the ſea-ſhores, are commonly the moſt pure from heterogeneous admixtures: the Land-Flints have often ſpecks or ſtreaks of a reddiſh ferrugineous matter, diſcoverable chiefly after they have been burnt or calcined. In ſome there are veins of native gold: one of the moſt curious ſpecimens of this kind is in the cabinet of his Pruſſian Majeſty.

Sparks from Flint and Steel examined.

The ſparks which iſſue from the colliſion of Flint and Steel, collected upon Paper and viewed with a microſcope, Flint. microſcope, appear to be globules of vitrified matter: A chemical examination diſcovers that they contain more of the Iron than of the Flint, changed into a kind of glaſſy Scoria (*a*).—Two Flints ſtruck againſt one another, project no viſible ſpark; nor do the fragments broke off ſeem to have ſuffered any change: But the Stones themſelves appear, in the

Phoſphorus. dark, luminous; ſome throughout the whole maſs, others only on the ſide ſtruck upon. The greater number of Flints I have examined is of this laſt kind.

Flint at a burning glaſs. Boerhaave relates, that Flint, placed in the focus of Vilette's burning ſpeculum, was inſtantly converted into glaſs. I have had no opportunity of trying that inſtrument; but have expoſed Flint to the action of the large burning lens of Tſchirnhaus, without being able to produce any ſuch effect. Though Flint, however, by itſelf, abſolutely reſiſts

Melted with Lime. that moſt vehement heat, and Quick-lime by itſelf equally reſiſts it; yet a mixture of the two runs with eaſe into glaſs (*b*).

Vitrification with Salts. Powdered Flint, mingled with a due proportion of fixt Alcaline Salt, melts eaſily in the common furnaces,

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(*a*) *Sparks from Flint and Steel.*] It does not appear that the Steel is here really vitrified, or that the heat produced is ſo intenſe as has been generally ſuppoſed. Among the particles of metal abraded by the Flint, there are indeed ſome globular ones which have evidently been melted: but the magnet ſtill attracts them; a mark that they are not ſcorified, but continue perfectly metallic. The fuſion of ſmall moleculæ of Steel does not require any very extraordinary heat: if fine Steel-wire be held barely in the flame of a candle, the end will melt, and form a little ball like thoſe obtained in the experiment of ſtriking fire with Flint.

(*b*) *Vitrification of Flint.*] Of all the ſaline matters that have been tried in compoſition with Flint, fixt alcalies moſt effectually promote its vitrification: two parts of the Alcali and three of Flint, urged with a ſtrong fire, form a perfect glaſs. Borax, by vehemence of heat, may be made to vitrify twice its weight, and even more; but the compound ſcarcely proves tranſparent, unleſs the Borax be equal in quantity to the Flint: a ſmall addition of Alcaline Salt to this mixture promotes both the fuſion and tranſparency: the glaſſes made with Borax, or with Borax and a little Alcali, prove rather harder than thoſe with the Alcaline Salt alone—Common Salt, Sal mirabile and Sandiver, are remarkably indiſpoſed to vitrify with Flint, though taken even in twice or thrice the quantity of the Stone: nor do they, in any proportions, form with it a pellucid glaſs.

naces, and forms the baſis of the fine white cryſtalline kinds of Glaſs, and of the compoſitions for imitating precious ſtones (*c*). Kunknel recommends the Sea-flints, as yielding a finer Glaſs, and requiring leſs Salt, than thoſe found on the land: others object to the marine Flints, that they make the Glaſs brittle and apt to crack. Thoſe which exhibit red veins when calcined, ſhould either be rejected, or freed from that extraneous matter, which would give a tinge to the Glaſs: this may be effected by waſhing the powder with Spirit of Vitriol or Aqua Regis, and afterwards edulcorating it with water. Such as have been pulveriſed in an iron mortar ſhould likewiſe be purified by the ſame means from the ferrugineous particles they may have abraded from the inſtrument, before they are employed in the compoſition of any curious Glaſs. White Sand is often ſubſtituted in the place of Flint, and does not conſiderably differ from it in quality (*d*). Calces of Lead are commonly added, for the colourleſs as well as coloured glaſſes, to promote the Vitrification.

Diſſolved in Alcalies.

Though a moderate proportion of fixt Alcaline Salt unites with Flint, in the fire, into a perfect glaſs, which is not diſſoluble in any liquor, and diſcovers no

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(*c*) *Vitrification of Flint with other earths.*] Powdered Flint has been mixed in different proportions both with Quick-lime and with Earths of each of the other claſſes, and urged with the moſt intenſe fires procurable in the common furnaces, without ſhewing any diſpoſition to melt: but theſe mixtures are brought into fuſion by a much leſs proportion of Salt than the ingredients ſingly would require. Though Alcalies are the moſt powerful flux for Flint by itſelf, Borax is found moſt effectually to vitrify the compounds.

(*d*) *Sand.*] Though the fine white Sands appear to the eye to be purer than Flint, they ſcarcely afford ſo clear a glaſs: the difference is the moſt perceptible when each of them is melted with a ſomewhat ſmaller proportion of Alcali than is ſufficient to bring them to their full tranſparency. Pott relates, that on melting Sand with half its weight of Nitre, he obtained a glaſs of a purple colour; probably from ſome metallic matter, of which moſt Sands participate in a greater or leſs degree.

The red and yellow Sands are manifeſtly impregnated with a ferrugineous calx. They contain alſo a minute portion of Gold; which is ſeparable from them in the way of aſſay, though no method has hitherto been found of extracting it to advantage in the larger works. Cramer and others preſume, that there is no Sand in nature intirely free from Gold. See *Gold*.

FLINT.

no mark of a ſaline nature; a ſomewhat larger proportion of the Alcali changes the Flint itſelf into an apparently ſaline form. If powdered Flint be mixed with thrice, twice, or even equal its weight of fixt Alcaline Salt, and a mixture melted in a crucible; the maſs, though it has a vitrious appearance, proves in taſte ſaline and fiery, like the Alcali itſelf; and, on being expoſed to the air, runs in a little time, Flint and all, into a colourleſs tranſparent liquor called *Liquor ſilicum*, or *Oleum ſilicis per deliquium* (*e*).

Coagulation of Liquids.

This liquor, on being mixed with mineral Acids, particularly the vitriolic, inſtead of effervefcing and uniformly mingling with them, as mere Alcaline Liquors do, grows inſtantly thick, and in ſome degree ſolid; as if the diſſolved Flint was going to reſume its original conſiſtence. It coagulates alſo with metallic ſolution made in Acids; that of Corroſive ſublimate, or of Mercury in the Marine Acid excepted; this ſolution yielding with the *Liquor Silicum*, as with pure Alcalies, an orange yellow Precipitate, and ſcarce diſcovering any tendency to become curdly. It likewiſe becomes conſiderably thick or conſiſtent, with ſome ſolutions of Earths in Acids, as that of Quick-lime in the marine. If loaded with the Flint, as the liquor prepared from equal parts of Flint and Alcali, it grows thick, upon ſtanding for ſome time, without any addition. The coagulum which it forms with ſolution of Mercury in the nitrous Acid appears variegated

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(*e*) *Deliquiation of Flint and Alcali.*] The proportion of Alcaline Salt for obtaining with Flint either a deliquiable or a truly vitrious compound, depends greatly on the degree and continuance of the fire. A mixture of powdered Flint with an equal quantity of the Salt, if taken out of the furnace as ſoon as it appears melted, will liquefy by degrees upon expoſure to the air: but if the fire is kept up ſtrong for ſeveral hours, though the quantity of Salt be more than doubled, the reſult will be a perfect and durable glaſs; all the ſuperfluous Alcali being diſſipated by the vehemence of the heat. One part of Alcali and two of Flint have been ſaid to deliquiate: But this mixture requires a very ſtrong fire for its fuſion; and when perfectly melted, proves a ſemitranſparent glaſs, of conſiderable hardneſs, ſo as freely to ſtrike fire with ſteel. Glaſs in general is found to be harder in proportion as it contains leſs Salt.

FLINT.

variegated, reddiſh, yellowiſh, and grey: the others are more uniform (*f*).

There have been many pretences of extracting from Flint, Salts, Spirits, Tinctures, *&c.* and many preparations of it recommended by the Chemiſts, both for medicinal and the ſublimer metallurgic uſes; from a groundleſs conceit, that this Stone was poſſeſſed of lithontriptic powers, and impregnated with a ſolar ſulphur. It has been ſaid that Flints, by repeated ignition and extinction in water, change at length into a ſlimy ſubſtance, from which may be procured, by diſtillation, a Spirit and an Oil: Becher, Stahl, Henckel and others mention this proceſs, and promiſe notable effects from it on metallic bodies: but, upon trial, an hundred repetitions of the extinction made no other change in the Flint than rendering it friable; nor did the water, in which the ignited Stone had been ſo often quenched, appear to have received from it any impregnation, which ſome pretend it does, or to differ ſenſibly from the pure water employed. Glauber and others recommend diſtilling the Flint with equal its weight or more of fixt Alcaline Salt: this mixture, if the fire is raiſed high enough to melt it, emits vapours reſembling thoſe of the acid of Sea-Salt: The maſs, deliquiated in the air, emits vapours of the ſame kind on the affuſion of Oil of Vitriol: it does not however follow that the marine Acid, extricated in theſe experiments, exiſted in the Flint; the Alcali, without the Stone, yielding the ſame marine vapours.

Contains Vitriolic Acid.

If any Acid exiſts in Flints, it ſhould ſeem to be the Vitriolic; and that they contain a portion of this, there is ſome foundation to preſume. If Flints be mixed

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(*f*) *Liquamen of Flints.*] The Flint is precipitated from this ſolution of it in fixed Alcalies, not only by Acids, but likewiſe, as the German editor obſerves, by Volatile Alcalies. The Earth thus recovered either by one or the other is found to be remarkably altered; to be now diſſoluble in Acids which it entirely reſiſted before. Sand and Cryſtal ſuffer the ſame change—Whether this effect is owing to a change made in the earth itſelf, or the ſeparation of any particular matter from it, has not hitherto been examined, though highly deſerving of enquiry.

Flint.

mixed with Nitre, and expoſed to a moderate fire, the Acid of the Nitre will be remarkably extricated; the known effect of the Vitriolic Acid alone. In a ſtrong fire indeed, the Flint as an Earth would expel the nitrous Spirit, by abſorbing and vitrifying with its alcaline baſis: but here the extrication happens long before the heat has been raiſed high enough for vitrification (*g*).

II. CRYSTAL.

Crystal.

Natural Hiſtory.

CRYSTAL is one of the hardeſt Stones next to the Gems (*h*): by ſome it has been ranked in that claſs. It is ſometimes colourleſs and pellucid as Glaſs; though often tinged of a yellowiſh, brown-

(*g*) *Probably Vitriolic Acid in Flint.*] In the making of common glaſs with Flint, when the quantity of matter is large, a ſaline ſubſtance ariſes to the ſurface during the fuſion, commonly called Sandiver or Glaſs-gall: this, though no Vitriolic Salt was employed in the compoſition, is found to participate largely of that Acid, and to be nearly ſimilar to Sal Mirabile. Did the Vitriolic Acid pre-exiſt in the Flint, or was it generated during the proceſs?

(*h*) *Gems.*] The Gems or precious Stones are the hardeſt of all natural bodies. Art has imitated moſt of them in other reſpects; but no artificial compoſition comes near them in point of hardneſs. They have been ſuppoſed to be entirely unſubduable by common fire; but experiment ſhews, that they calcine and become pulverable like the other Stones of this claſs, though more difficultly in proportion to their greater hardneſs. The Diamond itſelf, as Pott obſerves, in a vehement fire, loſes all its luſtre and tranſparency, becomes milky, friable, and ſplits into fine leaves like Talc. The Hyacinth and Garnet come at length into actual fuſion; changing their red colour to a dark black, but preſerving even in this form a great degree of hardneſs: both the colour and fuſibility of theſe Stones appears to proceed from Iron, a portion of which is ſeparable from them by the Magnet. The blue tincture of the Sapphire, the purple of the Amethyſt, and the green of the Emerald, are more periſhable; being totally deſtroyed by a moderate degree of heat, ſo as to leave the Stones colourleſs as Chryſtal. The Emerald, in loſing its colour in the fire, tinges the flame bluiſh.

Mr. Pott, in the Berlin Memoirs, has given a curious ſet of experiments on the Saxon Topaz, which is reckoned the hardeſt of all the Stones, except the Diamond, Sapphire and Ruby. This Stone, reduced to powder after ignitions and extinctions, refuſed to melt with even ten times its weight of fixt Alcaline Salt; great part of the Alcali tranſuding through the crucible, inſtead of acting upon the Topaz. A portion of Sea-Salt was added to the Alcali without any better ſucceſs; but, on adding Borax, the caſe was altered: two parts of Topaz, with

no

brownish, or other colours. It is generally of a regular figure, namely, that of an hexagonal column with unequal ſides, terminated by an hexagonal pyramid; in rivers, it is ſometimes found with the angles rounded off, and ſometimes quite round. The maſſes are commonly ſmall, though ſometimes of conſiderable magnitude. In the Breſlau Collections for the year 1725, there is an account of a piece of Cryſtal found near Zittau, and thence brought to Dreſden, which weighed upwards of four hundred weight. In the Imperial Collection at Vienna, there is a pyramidal Cryſtal Vaſe two ells in height, cut wholly out of one piece——Pieces are ſometimes met with, which have different foreign bodies included within them: I have ſeen leaves and ſtalks of Plants, Hay, Straw, Hogs Briſtles, incloſed in ſprigs of Cryſtal.

CRYSTAL.

Vitrification.

Cryſtal is ſomewhat more difficultly fuſible than Sand, and is ſaid to afford a ſomewhat harder Glaſs: it requires by itſelf about an equal weight of Alcali for its vitrification; of Borax, if mixed with a little Lapis Specularis, a ſmaller proportion proves ſufficient. With half its weight of Alcali, it formed a violet blue maſs: by varying the proportions, I have obtained

no more than one of Alcali and one of Borax, melted into a tranſparent glaſs, in colour inclining to be yellow. On taking Nitre inſtead of Alcaline Salts, the event was the ſame: in whatever proportion Topaz and Nitre were mixed, they reſiſted vitrification; but by the mediation of a proper quantity of Borax, they melted perfectly together. Borax alone alſo was found to bring the Topaz into fuſion, and this even when the quantity of the Borax was no greater than one half of that of the Stone. The powdered Topaz, mixed with thrice its weight of Chalk, vitrified, in a vehement fire, without any ſaline addition at all. It melted likewiſe, not only with the fuſible Calces of Lead, but with the unfuſible ones of Copper.

The Topaz appears from theſe experiments not to conſiſt wholly of Cryſtalline Earth; ſince the pure Cryſtalline Earth vitrifies more eaſily with Alcaline Salts than with Borax, and does not vitrify at all with Chalk. Any of the other ſimple Earths, mixed with the Cryſtalline, renders it more eaſily fuſible with Borax than with Alcali; but the only one that renders it fuſible with Chalk is the Argillaceous: hence it is not unreaſonable to ſuſpect, that the precious Stones are compoſed of the Cryſtalline Earth mixed with the Argillaceous. If this ſhould be the caſe, the proportion of Argillaceous Earth cannot be large; for if it was, the Stone, inſtead of growing friable, would gain additional hardneſs in the fire.

CRYSTAL.

obtained brighter and darker blues, and browniſh red compounds (*i*). Like the other bodies of this claſs, it reſiſted the ſolar heat, and ſaline Menſtruums; and gave no impregnation to Water on being repeatedly quenched in it. Becher pretends to reduce it into the conſiſtence of a Jelly, that ſhall flow in a moderate heat like Wax.

Methods of colouring.

Cryſtal may be tinged of a variety of colours, by expoſing it in a cloſe crucible to the vapours of Orpiment, or of Antimony and Arſenic (*k*); or by quenching the ignited Stone in coloured liquors: Tincture of Cochineal gives a bright red; Tincture of red Saunders, a dark red; Tincture of Saffron, according as it is more or leſs ſaturated, a dark and a bright yellow: Solution of Lacmus, a bright blue; Juice of Buckthorn Berries, a violet blue;

(*i*) *Blue and reddiſh maſſes from Cryſtal.*] Probably the Cryſtal, employed in theſe experiments, participated of cupreous or other heterogeous tinging matters, for pure Cryſtal gives a colourleſs Glaſs. That this Glaſs is either harder or more tranſparent than ſuch as is made from Flint, as it is commonly ſuppoſed to be, did not appear upon compariſon.

(*k*) *Colouring of Cryſtal.*] This method of colouring Cryſtal was firſt deſcribed by Neri in his art of Glaſs*. He directs Antimony and yellow Orpiment of each two ounces, and one ounce of Sal Ammoniac, to be mixed together and put into a crucible; and ſome pieces of clear Cryſtal to be laid above the mixture, the ſmaller ones at the bottom and the larger at top, 'till the veſſel is full: another crucible, having a ſmall hole in its bottom, is to be inverted into the former by way of cover, and the juncture cloſely luted: the whole is then to be placed in a convenient furnace, and ſurrounded with charcoal to about half the height of the upper crucible: the fire is to be raiſed by degrees, kept up, gentle, 'till the fumes diſappear, and then ſuffered to go out of itſelf; care being taken to avoid the poiſonous vapours; the uppermoſt pieces of Cryſtal are found tinged with Gold, Ruby, Opal, and other beautiful variegations; and moſt of the lower ones of a viper colour. He gives another proceſs, in which the ingredients are, yellow Orpiment and white Arſenic of each two ounces, and Crude Antimony and Sal Ammoniac of each one ounce.——The Cryſtal, in theſe operations, receives very elegant colours, but is apt to become full of cracks, and hence unfit for being cut or poliſhed. Kunckel ſuppoſes the colour to be wholly owing to the Fiſſures of the Stone retaining the colouring particles: but though this is often, it is not always the caſe, ſome pieces being tinged throughout, without any viſible fiſſure: his own words inſinuate, that ſome receive the full tincture, without thoſe imperfections. I have known bodies of the Cryſtal kind, or at leaſt equal to Cryſtal in compactneſs and tranſparency, penetrated above an inch by certain vapours, though not the leaſt fiſſure or imperfection could be diſcerned.

* Book iv. Chap. 73.

blue; a mixture of Solution of Lacmus and Tincture of Saffron, a green. CRYSTAL.

CLASS II. CALCAREOUS EARTHS and STONES.

Earths and ſoft Stones; — reducible by fire into Quicklime; — readily ſoluble in the nitrous, marine, and vegetable Acids, both in their natural ſtate and when calcined.

I. CHALK.

CHALK. Natural Hiſtory. CHALK is a white Earth, found plentifully in England, France, Norway, and other parts of Europe; ſaid to have been anciently dug chiefly in the iſland of Crete or Candy, and to have thence received the name *Creta.* Some attribute the excellency of the grapes and the wines of Champagne to the chalky ſoil abſorbing acid juices; a theory which would be abundantly plauſible, if the unripe grapes had no acidity.

The beſt Chalk is of perfect whiteneſs, ſoft yet cloſe and ſolid, equal and uniform when broke, free from Sand or ſmall Stones. Powdered, and waſhed over from any gritty matter that may be naturally intermixed, it is called Whiting; and in this ſtate is beſt adapted for medicinal and chemical uſes, as well as the œconomical ones of cleaning and poliſhing metalline or glaſs utenſils, *&c.* Chalk readily imbibes water; and hence maſſes of it are employed for drying Precipitates, Lakes, earthy powders that have been levigated with water, and other moiſt preparations.

With Acids. Oil of Vitriol poured upon Chalk raiſes a ſtrong efferveſcence with a bituminous vapour, but ſcarcely diſſolves any of the Earth: if more and more of the Acid be gradually added, the whole continues quiet, without any further efferveſcence or ſolution. If the Acid be diluted with water, it diſſolves ſome portion

of

CHALK.

of the Chalk (*l*). All the other Acids readily and totally diſſolve it: four ounces of Spirit of Nitre took up one ounce; the ſame quantity of Spirit of Salt, ſix drachms; and the ſame quantity of diſtilled Vinegar, three drachms. The action of the nitrous Acid was accompanied with a conſiderable frothing, but no heat or red fumes.

Solutions of Chalk in the nitrous and marine Acids, are extremely bitter; thoſe made in diſtilled Vinegar are much leſs ſo. None of them perfectly cryſtallize; nor, if inſpiſſated, do they long retain a dry form: how carefully ſoever they be exſiccated by fire, they deliquiate again in the air, though one more readily than another. It has been ſaid, that Chalk forms with the Vitriolic Acid a perfect Alum: it may indeed be combined with that Acid into a cryſtalline form, but the Cryſtals prove extremely different, in taſte as well as in their other qualities, from thoſe of Alum: the Aluminous Earth is a ſubſtance of a peculiar Kind, hitherto nowhere diſcovered but in the Alum itſelf, (See Alum). Solution of Chalk in the nitrous Acid forms, on evaporation, a tenacious maſs like Turpentine; which exſiccated, and calcined a little, proves luminous in the dark. This Phoſphorus is uſually diſtinguiſhed by the name of its firſt diſcoverer, Balduin: it is called alſo *Phoſphorus Hermeticus*, from its being kept in hermetically ſealed glaſſes to ſecure it from the air. It differs from ſome other Phoſphori, in appearing in ſome degree luminous,

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(*l*) *Chalk with the Vitriolic Acid.*] Chalk does not diſſolve, or but in ſmall quantity, in the Vitriolic acid, whether concentrated or diluted. This Acid has nevertheleſs a very ſtrong affinity with Chalk; abſorbing it from all the other Acids, and forſaking even Alcaline Salts to unite with it. If this Earth be diſſolved in Spirit of Nitre, Spirit of Salt, or diſtilled Vinegar, the addition either of the pure Vitriolic Acid, or of compound Salts containing it, renders the liquor inſtantly milky or curdly; the Chalk being now combined with that Acid into a concrete, not at all, or exceeding ſparingly, diſſoluble. If the Solution of Chalk be largely diluted with water before the addition of the Vitriolic Spirit, the liquor continues for a time tranſparent: on ſtanding it becomes wheyiſh, and at length depoſites cryſtalliform concretions, which are found to be true Selenitæ or gypſeous Maſſes; being indiſſoluble in Acids, calcining in veſſels into Plaſter, and in contact with the fuel into Quick-lime.

after expoſure to the light of a taper as well as of the ſun.

Coagulation.

Chalk is precipitated, from its ſolutions in both the mineral Acids, by volatile and by fixt Alcalies, into a white powder; provided the Solutions are conſiderably diluted with Water. When the undiluted Solutions are mixed with ſaturated Alcaline Liquors, inſtead of a precipitation, the mixtures coagulate, and become ſo thick, that the glaſs may be turned upſide down without ſhedding its contents.

Vitrification of Chalk.

Pure Chalk melts eaſily with Alcali and Flint into tranſparent colourleſs Glaſs *(m)*. Calcined, by a ſtrong

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(m) Vitrification of Chalk.] Chalk vitrifies with Alcaline Salt ſomewhat more difficultly, and with Borax ſomewhat more eaſily, than Flint or Sand: it requires about equally its own weight of the Alcali; of Borax half its weight is ſufficient: the glaſſes made with both, particularly thoſe with Borax, are commonly of a fine pale green or yellow colour. Sal Mirabile and Sandiver, which do not vitrify at all with the cryſtalline Earths, form, with half their weight of Chalk, the firſt a yellowiſh black, the latter a greeniſh Glaſs. Nitre, on the other hand, one of the moſt active fluxes for Flint, does not perfectly vitrify with Chalk.

Vitrification of Calcareous with other Earths.] Chalk notably promotes the vitrification of Flint; a mixture of the two requiring leſs Alcali than either of them ſeparately: If Glaſs made from Flint and Alcali be ſaturated with the Flint, ſo as to be incapable of bearing any further addition of that Earth, without becoming opake and milky, it will ſtill, in a ſtrong fire, take up a conſiderable proportion, one fourth or one third its weight, of Chalk, without injury to its tranſparency. Hence Chalk is ſometimes employed in compoſitions for Glaſs, as a part of the Salt may then be ſpared.

Mixtures of Chalk with pure white Clay melt without any addition: they are difficultly brought to perfect tranſparency in veſſels; but if expoſed to the immediate action of the fire, in contact with the burning fuel, they vitrify with eaſe. I have made covers for crucibles of ſuch a compoſition, and unexpectedly found them melt, in no very vehement heat, into a hard, tranſparent, yellow Glaſs; they often melted and dropt down into the crucible before the vitreous compoſitions included in it had begun to run. The addition of Flint or Sand promotes the vitrification.

Mr. Pott has given ſome intereſting experiments of the effects of Chalk on the ſtony matters intermixed among or inveſting metallick Ores. Some of theſe Stones are ſo hard as to ſtrike fire with Steel, and either pellucid and colourleſs, or leſs tranſparent and ſomewhat milky. Others are ſo ſoft as to be cut with a knife, remarkably heavy, when pure of a milky whiteneſs inclining a little to yellow, generally of a leafy or ſhivery texture, ſometimes tinged with red, green, and other colours reſembling thoſe of the Gems, whence the names *Pſeudo hyacinthus*, *Pſeudo-ſmaragdus*, &c. Of theſe ſofter Stones there are two different kinds, ſtrong fire into Quick-lime, it loſes much of its diſpoſition to vitrify: it is now found to melt very difficultly and imperfectly, and render the glaſs milky. In either ſtate it does not vitrify of itſelf in the moſt intenſe fires; and is ſuppoſed in ſome meaſure to reſiſt the action of Glaſs of Lead, Luna Cornea, and ſome other ſubſtances, which ſoon corrode and penetrate the common earthen veſſels: hence ſome have been accuſtomed, for detaining thoſe bodies in fuſion, to line the crucible with Chalk made into a paſte with Solution of Borax.

Chalk with Antimony.

Chalk added to Antimony in fuſion is ſaid to abſorb the ſulphureous part of that Mineral, and precipitate the Reguline or Metallic to the bottom. On trial this experiment did not ſucceed: two ounces of powdered Chalk being ſtirred, with a clean tobacco-pipe, into four ounces of melted Antimony; and three ounces of Chalk mixed in the ſame manner with five ounces of Antimony; there was no ſeparation, in either caſe, of any Regulus; the whole remaining equally mixed. That the Chalk had nevertheleſs acted upon the Sulphur, appeared upon boiling a little of the maſs in water: the liquor became tinged, as from Sulphur combined with Alcalies, and on the addition of Vinegar, depoſited a Precipitate reſembling the golden Sulphur of Antimony.

Henckel,

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kinds, ſcarce to be diſtinguiſhed by the eye, but eaſily by a little Aqua fortis, which effervesces with and diſſolves one ſort, but has no action on the other. —— The ſoluble ſoft Stones, and the pellucid hard ones, are little affected by Chalk: the indiſſoluble ſoft, and the milky hard ones, though entirely unfuſible of themſelves, melted readily with this Earth, flowed thin as water, and, when the fire was kept up for ſome time, run clean through the crucible. Whether the Chalk or the Stone prevailed in the compoſitions, whether four parts of the Chalk were taken to one of the Stone, or four parts of the Stone to one of Chalk, the ſame ſurpriſing fuſibility was always obſerved. Theſe mixtures brought Earths of all the other claſſes alſo into fuſion along with them; and when ſaturated with theſe, were leſs apt to corrode the veſſel. Different calcareous bodies, as Chalk, Lime-ſtone, Marble, had the ſame effects: but the mineral Stones differed a little in point of fuſibility, the ſoft being more fuſible than the hard. — Theſe experiments may probably be applicable to valuable purpoſes in the running down of Ores.

CHALK.

Silver produced.

Henckel, in his Pyritologia, relates a remarkable experiment of a granule of Silver being obtained by barely roaſting the common ſulphureous Pyritæ with Chalk; though neither one or the other, examined ſeparately with different additions, diſcover any footſtep of that metal. I have treated Chalk with various inflammable ſubſtances, without being able to obſerve the leaſt mark of any thing metallic. With ſimple inflammable matters, as Tallow, Pitch, Wax, powdered Charcoal; the Chalk remained a white, remarkably ſpongy, light, crumbly maſs, notably diminiſhed in weight: from two ounces of Chalk and one ounce of Charcoal, no more than an ounce was left; all the reſt being volatilized *(n)*. With fixt Alcalies, on the other hand, it melted into a compact vitreous maſs, whoſe deficiency in weight was only half an ounce upon two ounces of Chalk and one ounce of the Alcali.

Chalk treated with inflammable ſubſtances.

With Sope.

It has been ſaid that Sope, diſtilled with Chalk, turns all to water: but on trial, this did not ſucceed. Chalk, which as we have already ſeen, unites eaſily with Alcalies in the fire, abſorbs the Alcaline Salt of the Sope; upon which the water of the Sope diſtils, along with its Oil, now rendered empyreumatic by the heat. If the diſtilled liquor be repeatedly drawn over from freſh parcels of Chalk, leſs and leſs Oil will be obtained in every diſtillation, till all the Oil is, as all Oils are by the ſame treatment, deſtroyed.

With Sal Ammoniac.

Chalk, mixed with Sal Ammoniac, extricates no urinous ſmell: but if the mixture be expoſed to the fire, the Chalk will then act upon the Salt, abſorb its Acid, and diſengage its Volatile Alcali, which is thus obtained in its proper concrete form. See Sal Ammoniac.

Medicinal uſes.

Chalk is employed, in medicine, againſt the heartburn, and other complaints ariſing from acidities in

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(n) *Chalk volatilized.*] All the calcareous Earths and Stones loſe a large proportion of their weight on being urged with a ſtrong fire without any addition: The harder the Stone, the leſs is the diſſipation. Chalk loſes near two-thirds of its weight in being burnt into Quicklime; the harder calcareous Stones, as Marble, about half their weight.

CHALK. in the firſt paſſages; and ſometimes as a deſiccative for running ſores and ulcers. It is the baſis of the cardialgic troches of the ſhops; to which ſome prefer Chalk itſelf in powder; the Sugar, which enters in large quantity in the troches, being often found to aggravate thoſe complaints. Chalk is more ſtyptic than moſt of the other abſorbent Earths, and therefore to be uſed with caution. Some have taken it freely, for procuring a white complexion; but its more certain effects are gripes and obſtructions. It is ſometimes employed for curing Wines or Malt Liquors on the fret; it takes off their acidity, but renders them very apt to grow vapid.

Stones in Chalk-pits In the Chalk-pits are found black or blackiſh brown ſemitranſparent Stones, ſo hard as to ſtrike fire with Steel. Many of theſe appear externally whitiſh and corroded as it were; and on being broke, prove gradually more compact, and darker coloured, from the ſurface to the center; as if the Chalk was produced from a corroſion and reſolution of the Stone by mineral vapours. On this preſumption, ſundry trials were made for obtaining a like reſolution by art. The Stones were calcined by the greateſt heat procurable in a potter's furnace: but they remained as compact and ſolid as at firſt, and, what is remarkable, loſt nothing of their weight. Calcination in mixture with Pit-coal ſucceeded no better; nor did expoſure to the fumes of Pit-coal, or of Sulphur, make any change in the Stone. The pulveriſed Stone, mixed with Sulphur, and calcined, ſuffered no diminution, nor any other alteration than becoming darker coloured. The Powder, both calcined and uncalcined, was examined alſo with Acids; but none of them had any action on it, except that oil of Vitriol acquired from the crude Stone a red tinge; which that Acid readily does from any thing impregnated, however ſlightly, with inflammable matter. Theſe Stones appear therefore to be of a different nature from Chalk, and to belong to another claſs [the Cryſtalline].

II. OSTE-

II. OSTEOCOLLA.

OSTEOCOLLA is a foſſil ſubſtance, found in ſandy grounds, in ſeveral parts of Germany; ſpreading from near the ſurface, to the depth of four, ſix, ten and more feet, like the roots of a tree; ſome of the ramifications are as large as a child's arm; others no thicker than a quill. Whilſt under the earth, it is ſoft, almoſt like ſlaked Lime tempered with Sand, ſo as ſcarce to be got up entire: in colour it is ſometimes yellowiſh or browniſh, but moſt commonly greyiſh or whitiſh. Dried it becomes whiter and harder, and ſometimes exhibits reddiſh or yellowiſh ſpecks or veins. Moſt of the pieces are internally hollow: ſome have a core of a corrupted woody matter.

OSTEOCOLLA. Deſcription.

The origin of this concrete has been greatly controverted, and greatly miſunderſtood. Moſt of the ancients imagined it to be petrified Bones, though it has no reſemblance in figure to any kind of Bone: ſome have ſuppoſed it a true mineral ſubſtance, proceeding from the finer parts of the Sand, among which it is always found, conglutinated together by ſubterraneous vapours; whence it has been named *Lapis Sabuloſus.* Ferrantus Imperatus, in his *Iſtoria Naturale*, firſt publiſhed in 1599, gives a copper-plate of three pieces of Oſteocolla, under this title: "Oſteocolla is a petrified root, compoſed of a ſoft cement and a ſandy ſubſtance, employed by the German phyſicians for conſolidating broken bones." That this is its true original, I have been convinced from ocular obſervation: After many fruitleſs ſearches, I found at laſt, near the village of Tſchernow or Tſcharno, the remains of the trunk of a tree with a living branch upon it, and its roots changed wholly into

Hiſtory.

A petrified root.

OSTEO-COLLA.

into Oſteocolla. The tree was the common black poplar, *Populus nigra, C. B.* (o)

examined by Acids, &c.

Diluted Spirit of Vitriol poured upon Oſteocolla, totally diſſolved it, with conſiderable effervesſcence: ſome cryſtalline concretions ſeparated from the liquor, but on adding more of the Acid they were taken up again: the Solution being inſpiſſated, the dry maſs was found to weigh one ſixth more than the Oſteocolla at firſt. The concentrated vitriolic Acid, on the other hand, diſſolved only eight grains out of ſixty; though more and more of the Acid was added to the Powder, ſo long as it occaſioned any effervesſcence: the colour of the Solution was a Gold yellow. Spirit of Nitre, Spirit of Sea-Salt, and Aqua Regis, diſſolved each twenty-four or twenty-five grains out of ſixty; nor would a freſh addition of either of theſe Acids take up any more: Aqua Regis ſeemed to act the moſt difficultly of the three, and when added in an over-proportion, after the Solution had been ſaturated, precipitated a part of what had been before diſſolved. Diſtilled Vinegar took up but ten grains, or one ſixth of the Oſteocolla.

(o) *Natural Hiſtory of Oſteocolla.*] The author's account of this curious foſſil is confirmed by the obſervations of Mr. Gleditſch, who, in the Berlin memoirs for the year 1748, has given a particular deſcription of it as met with in the marquiſate of Brandenburg. It is dug among Sands, which are ſaid to have been once covered with foreſts, where ſome Pines and Birches ſtill remain, and where he found a living Pine with part of its root changed into Oſteocolla. The Oſteocolla is externally full of knobs, and often has a cavity running along one ſide: no mark is left of the Bark or woody circles, but ſometimes, though rarely, the Parenchyma is found at the extremity of the root: no ſmall fibres are ſeen, but there are protuberences and cavities, which plainly diſtinguiſh the places where they iſſued from: ſome pieces, eſpecially the larger ones, are encloſed in a particular kind of ſubſtance, not very compact, conſiſting manifeſtly of the mouldered Bark and rotten woody parts. Some large branches diſcover, on breaking, the remains of the petrified wood; others have a hard woody core almoſt like Horn, extending ſometimes to the length of five or ſix feet. The ſubſtance of the Oſteocolla is internally ſoft and of a looſe texture; externally harder and ſandy, ſometimes, eſpecially in the ſmall branches, ſo hard as to ſtrike fire with Steel.

The Sands in which the Oſteocolla is met with, have an admixture of of a fine white calcareous Earth, which ſticks to the fingers, looks like meal, and when waſhed down from the higher grounds by rains, and collected in cavities, and appears in form of an emulſion. The Sand adjoining to the Oſteocolla abounds moſt with this Earth; and the foſſil itſelf appears to be compoſed of the ſame Earth mixed with the Sand. If powdered Oſteocolla be agitated with water, the calcareous Earth remains for a time ſuſpended, ſo as to be poured off with the liquor, whilſt the Sand is left behind. The Sand and Earth are nearly in equal proportions.

OSTEOCOLLA.

Diſtilled Water, long boiled with an ounce of Oſteocolla, appeared, after repeated filtrations, turbid and milky. On ſtanding for a length of time, it depoſited a ſcruple of an extremely fine Powder, and became clear: the liquor being now examined by Alcalies, Acids, and Syrup of Violets, gave no marks of its having received any Saline impregnation from the Oſteocolla. Alcaline Lixivia boiled with this concrete, appeared upon moſt trials to be ſtill merely Alcaline; but on adding to the inſpiſſated liquor ſome oil of Vitriol, vapours aroſe like thoſe of Spirit of Sea-Salt, and on ſtanding for a length of time, a little ſlippery curdly matter ſeparated.

By diſtillation.

Forty-eight ounces of freſh Oſteocolla, diſtilled in a glaſs retort, gave firſt eight ounces of an almoſt inſipid and inodorous phlegm; then three ounces of a bituminous liquor, and at laſt one ounce of a ſtronger ſpirit, which ſmelt conſiderably of Petroleum, effervеſced with Oil of Vitriol, and changed Syrup of Violets green. Freſh ſoft Oſteocolla, diſtilled with Oil of Vitriol, in a tubulated retort, yielded an Acid Spirit, the ſame with that of Sea-Salt: by ſaturating the Spirit with Salt of Tartar, I obtained a true regenerated Sea-Salt: and by diſtilling this Salt again with Oil of Vitriol, a concentrated Spirit of Salt. Freſh Oſteocolla, which had been boiled in water, ſtill yielded with the Vitriolic Acid a Marine Spirit.

By calcination and vitrification.

Oſteocolla calcined in an open fire, loſt in weight four ſcruples upon half an ounce, and became ſomewhat duller in colour: Water boiled on the calx, made no efferveſcence on the admixture of Alcalies, and depoſited no Precipitate; but Oil of Vitriol mixed with it extricated vapours of Marine Acid. Equal parts of powdered Oſteocolla and fixt Alcaline Salt, urged in a crucible with a ſtrong fire, melted into an untranſparent vitreous matter, moderately hard, and

OSTEO-COLLA.

of a grey colour: Water extracted from this maſs a part of the Alcali, as appeared from the liquor changing Syrup of Violets green (p).

III. LIME-STONE.

LIME-STONE. Natural Hiſtory.

LIME-STONE is a general name for all the Stones from which Quick-lime is commonly prepared. Of theſe there are a great variety: ſome are pale coloured, grey, whitiſh, or yellowiſh; others darker, browniſh, or reddiſh: ſome are of a ſpongy, ſcaly, or ſhivery texture; others cloſe and compact: ſome entirely opake, others ſemitranſparent. They are of all degrees of hardneſs, from Chalk up to Marble; which laſt is the hardeſt of the Stones that are convertible into Lime. The ſofter kinds are generally made choice of for burning: and the harder employed as building ſtones or for other uſes: the Lime uſed about London is made chiefly from Chalk. Sea-ſhells likewiſe afford a good Lime, and in ſome maritime places ſupply the want of the proper mineral Stones.

Contains Acid, &c.

All Lime-ſtones contain a portion of ſulphureous matter, as is evident from the ſtrong ſmell which ariſes

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(p) *Chemical hiſtory of Oſteocolla.*] Mr. Margraff, in the memoirs above-mentioned, has given a more particular examination of this Concrete. Eight ounces of one of the pureſt pieces (taken from a pine-tree) were ſeparated, by waſhing over with water, into four ounces and a half of white Earth, and three and a half of Sand. —— The Earth efferveſced with Acids, and formed with them the ſame compounds as Chalk or Limeſtone: Uniting with the Vitriolic into a thick ſubſtance like pap, which diluted with water yielded on evaporation a few ſmall oblong Cryſtals; almoſt totally diſſolving in the nitrous and marine, refuſing to cryſtallize with either, when exſiccated by fire deliquiating again in the air; yielding with the nitrous a Phoſphorus, the ſame with that of Balduin formerly mentioned. Calcined, it became a true Quick-lime, not differing on any trial from the common Limes. —— The Sand of Oſteocolla, melted with a equal quantity of fixt Alcaline Salt, yielded a Glaſs of a fine yellow colour, probably from ſome admixture of ferrugineous matter: the calcareous Earth, like common lime, formed with twice its weight of the Salt only an opake whitiſh maſs. —— Eight ounces of Oſteocolla entire, diſtilled in an earthen retort by a ſtrong fire, gave two drachms of an empyreumatic volatile Alcaline Spirit: in diſtillation with Oil of Vitriol, no other than mere phlegm was obtained.

LIME-STONE.

ariſes in burning them, and which extends to a conſiderable diſtance from the kilns. The Lime-ſtones uſed in this country yielded in diſtillation an Acid Liquor, which turned Syrup of Violets red, precipitated Solution of Silver, and formed with Mercury a corroſive Sublimate; a proof that the Acid was marine. The ſame Acid was diſcovered alſo after the Stone had been burnt into perfect Lime; Oil of Vitriol extricating from the Calx vapours manifeſtly marine. The Limes prepared from different Stones, though they may anſwer equally for morter and other common uſes, are found to differ conſiderably in ſome of the nicer chemical experiments.

IV. QUICK-LIME.

QUICK-LIME.

General properties.

QUICK-LIME is an acrid Calx, ſo corroſive as to be employed by the tanners for deſtroying the fat and fleſhy parts of ſkins, and occaſioning the hair to ſeparate. It raiſes a ſtrong heat and ebullition on the affuſion of water, and in part diſſolves; rectified Spirit of Wine has ſcarcely any action on it, and oils none at all. Slaked with water, or moiſtened into the conſiſtence of a paſte, and mixed with a proper quantity of Sand or other hard bodies, it acquires a notable degree of hardneſs on expoſure to the air; hence morter and cements *(q)*: A large quantity of water impairs or deſtroys this property. The vapour which ariſes

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(q) Morter and Cements.] Lime made into a paſte with water alone, acquires on expoſure to the air ſome degree of hardneſs, which ſeems to be proportionable to that of the original Earth or Stone which the lime was made from; the Chalk Limes remaining ſoft and crumbly, whilſt thoſe prepared from Marble become notably hard. If either of them be mixed with glutinous liquors, as Milk, Blood, Solution of Gum, or beat with Cheeſe ſoftened by boiling in Water, they become harder than by themſelves, and in a ſhorter time: hence the uſe of theſe compoſitions for joining cracked Glaſſes, *&c.* Lime mixed with Sand, or other hard ſtony bodies in coarſe Powder, forms a concrete ſtill harder, and whoſe hardneſs is increaſed by length of time; whence in part the remarkable induration of the morter of ancient buildings. With Sand or Flint in fine Powder, it did not ſeem to grow harder than by itſelf: nor did any of the Earths of the other claſſes ſenſibly improve its conſiſtence.

Singular Spirit in its extinction.

ariſes during the extinction, collected by diſtillation, proves a liquor of a very ſingular kind. It changes Syrup of Violets green, and being mixed with Solution of Sublimate throws down an orange yellow Precipitate; as if the diſtilled Spirit was not only alcaline but a fixed Alcali: it precipitated alſo Solution of Sulphur made in Alcalies, as if it was an Acid. In ſlaking a pound and a half of Quick-lime, an ounce of this liquor was collected.

Quantity diſſoluble in water.

The quantity of Lime diſſoluble in water is much greater than is generally ſuppoſed. In the common method of making Lime-water, with only a ſmall proportion of liquor, the Lime loſes little; but if the reſiduum be repeatedly boiled in large quantities of freſh water, almoſt half the Lime will at length be diſſolved (*r*).

Agreement of Lime-water with Alcalies.

Lime-water turns Syrup of Violets green; added to Solution of Sublimate (*s*), throws down a yellow Precipitate; unites with Oils into a ſemiſaponaceous maſs;

(*r.*) *Lime with Water.* This property of Quick-lime, of impregnating a very large quantity of water, has been remarked alſo by Dr. Alſton, and confirmed by a number of experiments, in a Diſſertation upon Quick-lime. He finds that about one third of the lime diſſolves; and that this requires for its Solution ſeveral hundred times its own weight of Water.

If the indiſſoluble part be calcined afreſh, it impregnates water in the ſame manner as at firſt; and by repetitions of the calcination, may at length be almoſt wholly diſſolved. On expoſure to the air, the Lime ſeparates from the Water, and proves inſipid like the crude Earth or Stone: by a freſh calcination it becomes Quick-lime again.

Quick-lime expoſed to the air, unmoiſtened, falls by degrees into Powder, and loſes its activity: if kept moiſtened with Water, it in great meaſure retains its acrimony, and its peculiar qualities, for years.

(*s*) *Lime water precipitates Mercury Sublimate.*] It has been preſumed that Lime-water would precipitate all the Metals, but experiment ſhews the contrary. Dr. Brandt obſerves, in the Swediſh Tranſactions for the year 1749, that neither Gold, Silver, Tin, or Copper are precipitated by it; that Iron is not precipitated at all from the nitrous or marine Acids, and but imperfectly from the vitriolic; that Quickſilver diſſolved in Aqua fortis, falls in part upon the addition of the calcareous liquor, but that a part ſtill remains ſuſpended; precipitable by an Alcaline one. He found that even Quick-lime in ſubſtance did not totally precipitate metallic bodies: A quantity of freſh burnt Quick-lime having been added to a Solution of Silver, and the liquor after due digeſtion poured off clear and paſſed through a filter; common and Alcaline Salts ſtill threw down a Precipitate, which yielded on reduction near one ſixth of the original quantity of Silver diſſolved.

Quick-Lime. and diſagreement, Volatilized. Artificial Selenites.

maſs; diſſolves Sulphur into a red Liquor. In theſe properties it agrees with fixt Alcaline Lixivià; there are others in which it as remarkably differs from them. Alcalies mixed with Lime-water, precipitate the Lime from it: on expoſure to the air, the Lime ſeparates ſpontaneouſly, ariſing in cruſts to the ſurface: in cloſe veſſels this ſeparation does not happen. Though the Lime in ſubſtance ſuſtains the moſt intenſe fires without diminution of its weight; the part which diſſolves in water, is, upon boiling the liquor, totally diſſipated in the air along with the watery vapour. Solution of Sulphur made by Quick-lime, on being kept for a length of time in a warm room, yields Cryſtalline Concretions, of the Selenitic kind, not diſſoluble in water (*t*).

Volatile Spirit of Sal Ammoniac with Quick Lime.

Quick-lime, mixed with Sal Ammoniac, immediately diſengages its volatile Alcali, without the application of any heat. But it produces at the ſame time a remarkable change in the Alcali itſelf; which, when extricated by Quick-lime, never aſſumes a ſolid form, but proves an extremely ſubtile Volatile ſpirit, much ſtronger and more penetrating in ſmell, and for ſundry bodies a more powerful menſtruum, than that prepared with fixed Alcaline Salts: the Spirit made with Quick-lime does not coagulate, like the other, with rectified Spirit of Wine, and hence is preferable

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(*t*) *Lime with Acids.*] The Selenitic Cryſtals, here obtained, were produced from the Lime combined with the Acid of the Sulphur: See p. 8.——The ſulphureous or vitriolic Acid, poured upon Quick-lime in ſubſtance, unites with it far more readily than with the Lime-ſtone or Chalk: it diſſolves very little of the crude Earth or Stone, and ſcarcely loſes any of its acidity: whilſt by Quick-lime, if the due proportion is hit, the whole of the Acid is inſtantly abſorbed, and the liquor left inſipid: The concretes, which the Earth in both ſtates forms with the Acid, are the ſame, a kind of Gypſum or Selenites.——The other Acids perfectly diſſolve Quick-lime, as they do the crude Earth, but without efferveſcence. The Solution made in the marine Acid coagulates with Alcaline Lixivià, and with the Vitriolic Acid; changes the colour of Syrup of Violets to a green, and hence has been miſtaken for an Alcali; and unites with expreſſed Oils into a butyraceous ſubſtance: inſpiſſated, it yields an highly penetrating ſaline maſs, which deliquiates in the air, diſſolves in rectified Spirit of Wine, flows in a ſmall heat, and does not part with its Acid in a ſtrong one: if the matter be incruſtated on iron-rods and ſtruck upon, it ſparkles and appears luminous through the whole extent of the ſtroke.

ferable as an ingredient in thoſe compoſitions where Alcaline and Vinous Spirits are mixed; nor does it effervefce conſiderably with Acids, though it precipitates moſt metallic ſolutions made in them.

A concrete. Salt obtained from it.

Though the volatile Alcali is in this ſpirit highly attenuated and ſubtilized into a fluid ſtate; it is recoverable again in its proper ſolid form. If the ſpirit be ſaturated with the Acid of Sea-Salt, the liquor duly evaporated and ſet to ſhoot, Cryſtals of true Sal Ammoniac will be obtained: and if from theſe we extricate the volatile Alcali by means of Chalk or of fixt Alcalies, it will now concrete into a ſolid maſs. During the ſaturation of the ſpirit with the marine Acid, a ſtron fetid ſmell ariſes.

Volatile Salts deſtroyed by Lime.

Zwelfer relates, that Stahl has borrowed the obſervation from him, that volatile Salts are totally deſtructible by Quick-lime. I have made ſundry trials for determining this point; and found, that with Quick-lime in ſubſtance, the deſtruction ſcarcely ſucceeds: for ſome Spirit of Sal Ammoniac having been diſtilled no leſs than twenty times from unſlaked Lime, a volatile ſpirit was obtained to the laſt. By Lime-water on the other hand, the volatile Alcali was quickly deſtroyed: a drachm of pure Volatile Salt being added to two quarts of Lime-water, much, but not all, of the volatility was loſt, and great part of the Earth of the Lime was precipitated: the mixture being digeſted, committed to diſtillation, and all the volatile part drawn off; the diſtilled ſpirit, mixed with freſh Lime water, occaſioned no further precipitation, and no longer diſcovered any degree of volatility.

Salt of Lime.

Some have pretended to extract a Salt from Lime, that ſhould diſſolve the human Calculus. Dr. Cyprianus, in London, worked on this ſubject for ſix years; and I proſecuted the inquiry under his inſpection, for three years longer; purſuing all the hints of Helmont, Paracelſus, and others, but without ſucceſs. Moſt of the cryſtalline concretes obtained from Lime, are rather earthy, ſtony, and ſelenitic, than ſaline: And when we gain any thing that is truly ſaline and ſoluble in water, a further examination diſcovers that it is chiefly adventitious, and has rarely any thing of the Lime in it. Two papers on the Salt of Lime, by Mr. du Fay, may be ſeen in the French memoirs for the years 1724 and 1732 (*u*). Dr. Pott has given ſome very curious experiments on the ſolution of Lime in Spirit of Nitre, in the *Miſcellanea Berolinenſia* (*x*).

QUICK-LIME.

Quick-lime is employed for many conſiderable uſes in chemiſtry and the chemical arts; as in the rectification of Malt-Spirits, empyreumatic oils, and volatile ſalts, from its property of imbibing and detaining groſs Oils; in the ſmelting ſulphureous and arſenical

Uſes of Lime.

(*u*) *Salt of Lime.*] On evaporating Lime-water, a ſmall portion of ſaline matter commonly remains: This has been ſuppoſed an eſſential part of the Lime; the principle on which its activity as a menſtruum depends. But experiments have ſhewn, that this ſubſtance has nothing of the diſſolving power of Lime-water: That it is different in different Limes, being ſometimes vitriolic and ſometimes marine; And that the ſtrong and pure Lime-water, made from Lime once elixated and calcined again, leaves no ſaline matter at all.

(*x*) *Experiments on Lime and Spirit of Nitre.*] The more remarkable of theſe experiments are as follows.——Concentrated Spirit of Nitre, poured upon heated Quick-lime, diſſolved it into a blood-red liquor; which mixed with half its quantity of the phlegm of Spirit of Nitre yielded in diſtillation an acidulous oily phlegm, condenſing like Spirit of Wine into Striæ; ſucceeded by a ſimilar ſtriative Spirit, ſomewhat more acid, in white fumes. The remainder, now of the conſiſtence of Honey, being further urged, gave over a highly corroſive Acid, in red vapours. The Caput Mortuum was auſtere, bitteriſh, and ſomewhat ſtyptic; and could not be made to appear luminous in the dark, as Chalk does when treated in the ſame manner.

The oily phlegm, boiled on freſh parcels of the Honey-like maſs till it had loſt both its oilyneſs and acidity, yielded on evaporation an elegant Salt, of a bitteriſh, nitrous, not diſagreeable taſte, which taken in a gouty caſe procured a gentle diaphoreſis, and a copious diſcharge by urine. The corroſive red Spirit being poured to this Salt, and the liquor evaporated, a fine Nitre was obtained, which deflagrated more quickly than common Nitre.

The ſpirit became ſtronger and more corroſive, by repeated cohobations on the Caput Mortuum. At the third cohobation it appeared of an oily nature, and proved oily to the touch; the red fumes, tranſpiring through a crack in the luting, took fire from a candle. Some fine Silver having been diſſolved in the cohobated ſpirit, the liquor diſtilled off, and the dry matter kept melted for ſome time, the maſs when cold looked blue; the diſtilled liquor being cohobated on this maſs, and drawn off again, the dry remainder appeared tinged throughout of a beautiful, deep ultramarine blue; on a third cohobation the matter

QUICK-LIME. arſenical Ores (*y*), from its abſorbing thoſe volatile ſubſtances, which would diſſipate a part of the metal; in making of ſope, for increaſing the activity of Alcaline Salts; in dying, particularly with Indigo, *&c.*

CLASS III. GYPSEOUS EARTHS *and* STONES.

Earths and ſoft Stones,—reducible into an inſipid Calx, by a moderate fire, which forms with water a tenacious paſte, and which by ſtronger calcination loſes that property;—in their natural ſtate not acted upon by any Acid;—becoming ſoluble in Acids, and ſimilar to Quick-lime, by calcination in contact with the fuel.

I. LAPIS SPECULARIS.

SPECUL. THE *Lapis Specularis* or *Glacies Mariæ* is a tranſparent concrete, commonly found in pretty large maſſes, which may be eaſily ſplit into a number of thin plates or leaves, ſometimes ſo broad as to be uſed

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matter grew whitiſh, and, at every ſucceeding one, whiter and whiter, till at length no blueneſs remained.——The ſpirit, ſet in digeſtion without addition, lets fall a notable quantity of a dark brown unfuſible Powder, which is probably a part of the Lime that had been volatilized by the Acid. Mr. du Hamel obſerves, that Quick-lime is by this Acid almoſt totally volatilized, ariſing with it in diſtillation in a liquid form.

(*y*) *Quick-lime in the ſmelting of ſulphureous Ores.*] It is commonly ſuppoſed that Quick-lime abſorbs Sulphur from all the metals; and hence ſome have preſumed that the addition of Quick lime to ſulphureous Ores would ſupply the place of calcination. This does not appear however to obtain. When Copper is blended with Sulphur and a little Iron, as in moſt of the rich Copper Ores, Quick-lime abſorbs and vitrifies with the Iron, leaving the Copper ſulphurated as at firſt. Sulphurated Iron, that holds no Copper, melts with Lime into one uniform maſs, without any ſeparation at all; and, when a large quantity of Iron is blended with Sulphur and Copper, the effect is the ſame, Quick-lime uniting equally with all the three. Dr. Brandt obſerves, that both Copper and Iron Ores, thoroughly calcined, melt eaſily with Quick-lime into Glaſs, probably from the action of the calcareous Earth on the ſtony matter of the Ore; (ſee page 10.) for, with pure calces of thoſe metals, it refuſes to melt. Quick-lime is, in general, much more difficult of fuſion, both with earthy and ſaline bodies, than the calcareous Earth or Stone in its natural ſtate.

uſed for lanterns. Its foliaceous texture has occaſioned it to be often confounded with Talc (z); from which it may be readily diſtinguiſhed, by the tranſparency of the entire maſs as well as of the ſingle leaves; by its glaſſy rather than unctuous ſmoothneſs, and rather a vitreous brightneſs than a ſilver hue; by the maſs being eaſily pulverable, and eaſily calcinable in the fire.

SPECUL.

II. SELENITES.

SELENITES.

THE Selenites reſembles in appearance ſometimes the Lapis Specularis, and ſometimes Cryſtal; but wants the leafy ſtructure of the one, as well as the hardneſs of the other. It is found both in large and in ſmall maſſes, always tranſparent, but not always free from cloudineſs; and ſometimes of a yellowiſh tinge. It eaſily calcines into Gypſum or Plaſter-

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(z) *Confounded with Talc.*] The Powder which Mr. Reaumur received from China, under the name of *Petuntſe*, as one of the ingredients in the Chineſe ware, and which, from ſome flaky or ſtrawy particles obſerved in it, he calls Talc, appears to have been an Earth of this kind; ſome of our Gypſums exhibiting a like ſtrawy texture, whence they are diſtinguiſhed by the name of *Gypſum Striatum.* He ſays this Chineſe Talc baked with Flints into a ſubſtance reſembling Porcelane, and that Talcs found in France did the ſame, a property belonging to all the gypſeous Earths, but to none of the true Talcs. ——The other ingredient in China-ware, called by the Chineſe *Kaolin*, is ſaid, by the ſame author, to be a ſpecies of Flint; but, from its forming with water a maſs tenacious enough to be made into the loaves in which it was brought over, it ſhould ſeem rather to be of an argillaceous kind.

Theſe ſuſpicions are confirmed by ſome experiments of Mr. Scheffer's (in the Swediſh Tranſactions for the year 1753) upon a ſpecimen of Petuntſe obtained from China. It was a glittering, ſemitranſparent, flaky maſs, like the *Lapis Specularis*, of a light greeniſh grey colour, and remarkably heavy. It was not acted upon by Acids; in the fire it burſt and fell in pieces, and calcined into a white Powder, interſperſed with a red ferrugineous matter. Calcined, in contact with the fuel, it emitted ſtrong ſulphureous vapours like the other Gypſa, and became quite white, conſiderably firm and coherent, and ſemitranſparent. A mixture of the powdered Stone with tobacco-pipe Clay yielded a Porcelane not fully ſo white as the Chineſe: This imperfection he attributes to the Clay, which, when burnt hard, is never of ſuch whiteneſs as the leſs burnt tobacco-pipes.

SELENITES.

Plaſter-of-Paris (*a*). A portion of ſelenetic matter is contained in ſundry waters, as thoſe of Pyrmont, and ſeveral of the mineral waters of France, as appears from the analyſes of them related in the memoirs of the French academy.

III. BOLOGNIAN STONE.

BOLOGN.

THIS Stone has become remarkable from its property of affording a Phoſphorus by calcination, firſt diſcovered by a ſhoemaker, Vincenzo Caſciarolo (*b*). The Stone is found in the hill called Monte

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(*a*) *Calcines into Plaſter-of-Paris.*] The Stones, from which Plaſter-of-Paris is uſually prepared, are of a granulated ſtructure, and ſemi-tranſparent; ſometimes compact and moderately hard, ſometimes lax and crumbly. The calcination is performed with a heat ſomewhat below ignition; the Stone ſeems as it were to liquefy and to boil, and emits aqueous vapours, and at length ſubſides into a ſoft Powder, the mark of the calcination being completed. The Powder, made into a Paſte with water, becomes quickly a conſiſtent maſs, of no great hardneſs, but ſonorous, and of a ſmooth ſurface; hence its uſe as cement, and for taking off impreſſions. The matter expands in becoming ſolid, receives no increaſe, but rather a diminution, of its hardneſs, on expoſure to the air, readily imbibes water, but is not acted on by any Acid. The further the Earth has been calcined, the Paſte hardens the more ſlowly, and proves the leſs tenacious, but more durable. Kunckel gives ſeveral receipts for tinging Plaſter of a variety of colours, by uſing, inſtead of plain water, coloured decoctions, as of red Saunders, Brazil-wood, Saffron, *&c.* and ſays the hardneſs may be improved by diſſolving a little Gum, or rather Iſinglaſs, in the liquor.

The gypſeous Earths calcined by a ſtrong fire, in immediate contact with the burning fuel, emit ſulphureous vapours, and become Quick-lime. The principle they have loſt in this operation is the vitriolic Acid; of which it is a diſtinguiſhing character, to form Sulphur with inflammable matters. The calcined Earth, combined afreſh with that Acid, regenerates Gypſum again; and the common Quick-limes, or unburnt calcareous Earths, yield with the ſame Acid the ſame compound.

(*b*) *Bolognian Stone.*] Mr. Margraf firſt obſerved that this property is common to the other Gypſums, when pure from metallic or other heterogeneous admixtures; and that the artificial Gypſums ſucceed equally with the natural. For preparing this Phoſporus in perfection, he directs the Stone to be pulveriſed in a glaſs-mortar, and the Powder made up into thin cakes with mucilage of Gum-tragacanth; a good wind-furnace being filled to about three-fourths its height with ſmall pieces of Charcoal, the cakes, thoroughly dried, are to be ſpread upon the unlighted pieces at the top, and the furnace filled up with more Charcoal: After the fire has burnt out, the cakes are found on the grate, and may be eaſily freed from the aſhes that adhere, by blowing. The light of theſe maſſes is ſometimes white, ſometimes like that of a burning

Monte di Paderno, about three miles from Bologna; as alſo on the Piedalbino at the foot of the Alps, about eight miles from the ſame city. It is met with chiefly after heavy rains; by which the looſe earth is waſhed off, and the Stone left bare. It is of various figures and ſizes: ſome maſſes weigh no leſs than eight pounds; but thoſe of an ounce or two anſwer beſt for making the Phoſphorus. BOLOGN.

Phoſphorus. The Phoſphorus is thus prepared. Some of the fineſt Stones are reduced into a ſubtile powder in a braſs mortar; and entire Stones, well cleaned or filed on the ſurface, and moiſtened with Spirit of Wine, are rolled in this Powder, and the proceſs ſeveral times repeated, till they are all over coated with the Powder; after which the Stones are calcined among burning Charcoal in a moderate wind-furnace. When grown cold, they are commonly cleared from the powdery cruſt, and wrapt up in cotton. The principal cautions in the operation are, that no iron inſtruments be made uſe of in the whole proceſs; that the coals be not too large, duſty, or foul; and that the Stones be ſuffered to grow thoroughly cold before they are taken out of the furnace.

This Phoſphorus, like that of Balduin, appears luminous in the dark, after being expoſed for a time to the ſun's light: if made in perfection, expoſure for a few minutes is ſufficient: The inferior kinds require ſometimes an hour or more. It proves more luminous when expoſed in a ſhady place, than to the direct rays of the ſun: Hot ſunſhine is apt to deſtroy its power. It has been diſtinguiſhed by different names; *Phoſporus bononienſis*, *italicus*, *mineralis*; *lapis lucidus* or *luminoſus*; *ignis frigidus*; *ſpongia ſolis*.

CLASS

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burning coal: A ſecond calcination generally increaſes their luminous quality.

Vitrification of gypſeous Earths.] The gypſeous Earths flow readily with Borax into a yellow glaſs, with Sal Mirabile into a fine greeniſh yellow, but do not perfectly vitrify with other Salts, unleſs the quantity of ſalt is large, and the fire extremely ſtrong. Mixtures of them with argillaceous Earths vitrify without any ſaline addition, eſpecially if expoſed to the immediate action of the fire. They do not melt with any pure Earth of the other claſſes; nor do they bake or cohere in the fire with any but the Cryſtalline.

CLASS IV. ARGILLACEOUS EARTHS *and* STONES.

Earths forming with water a tenacious Paſte, or ſoft Stones;—burning hard (c)*;—corroded by ſtrong coction in the concentrated mineral Acids, but not acted on by moderate digeſtion.*

I. BOLES.

BOLE ARM.

THREE kinds of Boles are ranked among medicinal Earths, Armenian, red, and white. That met with in the ſhops under the name of Armenian

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(c) *Tenacious Paſte—burning hard.*] Theſe are the properties of Clays, on which their utility depends as the baſis of Earthen-wares. When ſoftened with water they prove ſo ductile and coheſive, as to be formed with eaſe into any figure; and, expoſed afterwards to the fire, they acquire a degree of hardneſs, which becomes greater and greater in proportion to the vehemence and continuance of the heat.

Pure Clay, ſoftened to a due conſiſtence for being worked, not only coheres together, but ſticks to the hands; in drying, it contracts an inch or more in twelve, and hence is very liable to crack, unleſs the exſiccation is performed exceeding ſlowly; in burning, it is ſubject to the ſame inconvenience, unleſs very gradually and equally heated. When thoroughly burnt, if it has eſcaped thoſe imperfections, it proves ſolid and compact, and ſo hard as to ſtrike fire with any Steel: Veſſels made of it are not penetrated by any kind of liquid, and reſiſt Salts and Glaſſes brought by fire into the thinneſt fuſion, excepting thoſe which corrode and diſſolve by degrees the Earth itſelf, as Glaſs of Lead; and even this penetrating Glaſs, there is ſcarce any other Earth that reſiſts ſo long: but, in counterbalance to theſe good qualities, they want the whiteneſs and ſemitranſparency required in ornamental vaſes, and cannot be heated or cooled, but with ſuch precautions as can rarely be complied with in common buſineſs, without cracking or flying in pieces.

Clay, that has once been expoſed to any conſiderable heat, and afterwards reduced to Powder, has no longer any degree of tenacity. Freſh Clay, divided by a due proportion of this Powder, proves leſs tenacious than by itſelf, not ſticking to the hands, though cohering ſufficiently together; it ſhrinks leſs in drying, is leſs apt to crack, and leſs ſuſceptible of injury from alternations of heat and cold, but at the ſame time leſs ſolid and compact. Conſiderable differences are obſerved in theſe reſpects, not only according to the quantity of the dividing matter, but according as it is in finer or coarſer powder.

Veſſels made with a moderate proportion of fine Powder, as half the weight of the Clay, are compact and ſolid, but ſtill very liable to crack from ſudden heat or cold; thoſe with a larger proportion, as twice or thrice the quantity of the Clay, are free from that imperfection, but ſo friable as to crumble betwixt the fingers. Nor does there appear to be any

BOLE ARM.

nian is not the produce of Armenia or any of the oriental countries, but, like the others, of different parts of Europe, as Bohemia, Sileſia, Saxony, Hungary,

any medium betwixt a diſpoſition to crack and to crumble ; all the compounds made of Clay and fine Powders, having one or the other, or both imperfections. — Coarſer Powders, about the ſize of middling Sand, form, with an equal weight of Clay, compounds ſufficiently ſolid, and much leſs apt to crack than the mixtures with fine Powders : Two parts of coarſe Powder, and one of Clay, prove moderately ſolid, and but little diſpoſed to crack : A mixture of three parts and one, though heated and cooled ſuddenly, does not crack at all, but ſuffers very fluid ſubſtances to tranſude ; ſolidity, and reſiſtance to quick viciſſitudes of cold and heat, ſeeming here alſo to be incompatible.

Different earthy matters, employed for dividing Clay, agree nearly in theſe general mechanical effects ; but they differ conſiderably in other reſpects, according to the chemical qualities of the particular Earth. (1.) Pure Clay, mixed with pure Clay that has been burnt, is no other than one ſimple Earth, and is neither to be melted, or ſoftened, or made in any degree tranſparent, by the moſt intenſe fires. (2.) Mixtures of Clay with gypſeous Earths burn whiter than Clay alone : In certain proportions, as two parts of Clay to three of Gypſum, they become, in a moderate fire, ſemitranſparent ; and, in a ſtrong one, they melt. (3.) Calcareous Earths, in ſmall proportion, bake tolerably compact and white, and, added to other compoſitions, ſeem to improve their compactneſs. If the quantity of the calcareous Earth nearly equals that of the Clay, the mixture melts into a yellow Glaſs ; if it conſiderably exceeds, the product acquires the qualities of Quick-lime. (4.) Veſſels made from Clay and Sand, in whatever proportion, do not melt in the ſtrongeſt fire, but they ſometimes bend or ſoften, ſo as to yield to the tongs : Glaſſes, in thin fuſion, penetrate them, by diſſolving the Sand : If gypſeous or calcareous Earths are urged in ſuch a crucible with a vehement heat, the veſſel and its contents run all into one maſs. In moderate fires theſe veſſels prove tolerably compact, and retain moſt kinds of Salts in fuſion ; but they are liable to crack, eſpecially when large, and do not long ſuſtain melted metals, being apt to be burſt by their weight : Such are the Heſſian crucibles. (5.) Flint forms whiter compounds than Sand, and hence is made uſe of as the dividing ingredient in the common white wares. (6.) Talc yields very compact maſſes, which freely ſtrike fire with Steel, and never melt or ſoften. (7.) Mixtures of Clay and Black-lead (which ſeems a ſpecies of Talc) are not liable to crack from alternations of heat and cold, but extremely porous : Hence Black-lead crucibles anſwer excellently for the melting of metals, and ſtand ſeveral repeated fuſions ; whilſt Salts, flowing thin, tranſude through them, almoſt as water through a ſieve : Sulphureous bodies, as Antimony, corrode them. Theſe mixtures, when only moderately burnt, prove ſo ſoft as to be cut with a knife ; a property for ſome purpoſes very valuable : Thus a door, *&c.* may be cut in a Black-lead pot, ſo as to make it a commodious portable furnace.

Pure Clay, ſoftened with water and incruſtated on earthen veſſels that have been burnt, does not adhere to them, or ſcales off again, upon expoſure to the fire ; applied to unburnt veſſels, it adheres and incorporates. Divided Clay unites with them in both ſtates.—Vitreous matters,

BOLE ARM.

gary, Tranſylvania, France, Norway, *&c.* The French employ chiefly the Bole of Blois. We need not be ſolicitous about the particular place where any of the Boles have been dug, provided they are pure and of a good quality.

Deſcription.

I. Bole Armenic is of a pale colour, between red and yellow, ſmooth and ſlippery to the touch, ſomewhat gloſſy, pure from Sand or any perceptible gritty matter. It readily crumbles betwixt the fingers, and adheres to the tongue. Softened with water, it forms a ſmooth Paſte: diluted with a larger quantity

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matters, melted in veſſels of pure Clay, adhere ſo firmly as not to be ſeparated; from veſſels of divided Clay they may be knocked off by a hammer.

The ſaline ſubſtances, which promote the fuſion of Clay, (beſides the common fluxes of all the Earths, Alcali, and Borax) are chiefly Arſenic fixed by Nitre, and the fuſible Salt of Urine; both which have little effect on the other Earths, though mixed with them in a large proportion. Nitre, which readily brings the cryſtalline Earths into fuſion, and Sal Mirabile and Sandiver, powerful fluxes for the calcareous, do not perfectly vitrify with Clay. Burnt Clay does not differ in theſe reſpects from ſuch as has not been burnt, nor in that ſingular property of vitrifying with gypſeous or calcareous Earths, without any ſaline or metallic addition; the utmoſt vehemence of fire ſeeming to deſtroy only its ductility, or that power by which it coheres when pulveriſed and moiſtened with water. It is ſaid that Clay, added in the compoſition of common Glaſs, makes it tougher, and leſs apt to crack.

The experiments, from which the foregoing general reſults are drawn, were made with the tougher kind of tobacco-pipe Clay, which appears to be one of the pureſt of the Earths of this claſs. There is a great variety of Clays, differing in the degree of tenacity of the Clay itſelf, as well as in the admixture of heterogeneous matters. The ſteatitic Earths or Stones (ſee the following note) are no other than Clays indurated, or deprived of their miſcibility with water: There are Clays of all the intermediate degrees of toughneſs, from theſe to the viſcid Pipe-clay. The Sturbridge Clay appears nearly a medium betwixt theſe two extremes: Hence it is made into pots for ſuſtaining the glaſs-houſe fires, without any addition to divide it, and cannot be worked, when mixed with ſuch large proportions of untenacious Powders, as the more viſcid Clays require. The loams, or brick Earths, are mixtures of Clay and Sand; the coloured Clays and loams participate of Iron; hence many of theſe melt in a ſtrong fire without any addition; both Clay itſelf, and mixtures of it with cryſtalline Earths, being brought into fuſion by ferrugineous calces, though the fuſible mixtures of Clay and calcareous Earths are, by the ſame ingredient, prevented from melting. The bricks made from ſome loams, particularly the Windſor, are, when moderately burnt, remarkably free, ſo as to be eaſily rubbed ſmooth, cut, ſawed, grooved, *&c.* Hence their uſe in building furnaces, *&c.* They bear a conſiderably ſtrong fire, but in a vehement one I have often melted them.

quantity of water, it remains for a conſiderable time ſuſpended. Bole Arm.

This Earth contains, beſides the purely argillaceous, a ſmall portion of one of a different claſs, which is extracted from it by Acids. In each of the following experiments were employed ſixty grains of the Bole. (1.) Spirit of vitriol diſſolved eight grains: The ſolution was clear; the died reſiduum grey. (2.) Spirit of Nitre diſſolved five grains: The ſolution appeared ſlightly yellowiſh; the reſiduum yellowiſh grey. (3.) Spirit of Salt, ſeven grains: The ſolution not green as Ettmuller relates, but of a gold yellow; the reſiduum of a pale ſulphur yellow. (4.) Diſtilled Vinegar diſſolved but two grains: The ſolution was clear, but taſted bitteriſh, whilſt thoſe made in the mineral acids were ſweetiſh: The reſiduum unchanged. (5.) Rheniſh Wine had the ſame effect as diſtilled Vinegar, except that the liquor proved in taſte leſs bitter. (6.) Freſh citron juice diſſolved five grains: The liquor was clear, thickiſh, and had a kind of vitriolic taſte: The reſiduum unchanged. (7.) Alcaline Lixivia, diſſolved nothing; but the Bole was found to have abſorbed a part of the Alcali, appearing when dried of a darker colour, and weighing fifteen grains, or one fourth, more than at firſt. (8.) Spirit of Sal Ammoniac on the other hand diſſolved two grains of the Bole: The reſiduum unchanged. (9.) Lime-water had no effect. (10.) Rectified Spirit of wine took up four grains, without occaſioning any further alteration. Examined by Acids, &c.

Four ounces of Bole Armenic, diſtilled in a glaſs-retort in an open fire, yielded three drachms of a ſaline phlegm, which ſmelt a little urinous, and changed Syrup of Violets green. In the neck of the retort was found a little powdery ſaline matter, which had an ammoniacal taſte, but it was in too ſmall quantity to be collected or further examined. Examined by diſtillation.

Bole Armenic, like moſt other coloured Earths, contains a portion of ferrugineous matter, to which its colour is owing, and which may be ſeparated by the Contains Iron.

BOLE ARM.

and vitriolic Acids.

the magnet after the Bole has been calcined with Oil or other inflammable matters. It is likewiſe impregnated with vitriolic Acid: And hence, when mixed with Nitre or Sea-ſalt, it extricates the Acids of thoſe Salts in the fire: It was probably by the Acid of the Bole, that the Alcaline Salt, in Exp. 7. was abſorbed and detained.

Medicinal uſe.

This Earth is employed medicinally as a ſtyptic, both internally and externally; a virtue which ſeems to proceed from its ferrugineous impregnation: To the antipeſtilential and alexipharmac qualities, for which it has long been celebrated, it has no pretence: And the foregoing experiments ſufficiently evince, that the abſorbent ones, which ſome aſcribe to it, have no juſt foundation. It is prepared or purified by waſhing over with water; the pure Bole remaining ſuſpended for a conſiderable time, ſo as to be poured off with the liquor, whilſt the ſandy or other groſſer matter remains behind; after the Bole has ſettled from the water, it is moderately dried, formed into rolls or cakes, and afterwards further exſiccated for uſe. Some have condemned this method of purification, as depriving the Bole of a certain central Salt, but this Earth contains nothing that water is capable of extracting; Bole Armenic, treated with water, remained undiminiſhed in weight, and neither the Bole or the water received any ſenſible alteration.

RED BOLE.

examined by Acids, &c.

II. The common red Bole is coarſer than the Armenian, and participates more largely of Iron; hence it is never given internally, unleſs to cattle. I examined it in the ſame manner as the Armenian, employing, with each menſtruum, ſixty grains of the Earth. (1.) Spirit of Vitriol diſſolved five grains; the Solution taſted like Vitriol of Iron; its colour was white, that of the remaining Bole browniſh grey. (2.) Spirit of Nitre diſſolved ſeven grains; the ſolution was yellowiſh, and of a vitriolic taſte, the reſiduum yellowiſh brown. (3.) Spirit of Salt diſſolved ſix grains; the liquor deep yellow, and of a vitriolic taſte; the reſiduum yellowiſh white. (4.) Diſtilled Vinegar took up but three grains; the liquor clear and ſweetiſh; the reſiduum rather darker coloured than the Bole was at firſt. (5.) Citron juice extracted five grains, and left the Bole ſomewhat paler; the liquor had an earthy kind of taſte. (6.) Rheniſh Wine diſſolved no more than one grain; the remaining Bole unchanged. (7.) A ſtrong fixt alcaline Lixivium received no tincture from the Bole, but was in part abſorbed by it, the dried matter weighing twelve grains more than the Earth employed; its colour was ſomewhat darker. (8.) Spirit of Sal Ammoniac diſſolved two grains; the liquor was clear; the remaining Bole ſomewhat darker. (9.) Limewater diſſolved three grains. (10) Rectified Spirit of Wine two grains. (11.) Common water had not the leaſt effect.

RED BOLE.

By diſtillation.

Four ounces of red Bole, diſtilled in an open fire, yielded two drachms and a half of urinous phlegm; the remaining Bole preſerving its original colour. On previouſly digeſting the Bole with a ſaturated alcaline Lixivium, ſomewhat more of the urinous matter was produced, and the diſtilled liquor had a volatile ſmell; an experiment which may deſerve further conſideration.

WHITE BOLE.

III. The white Bole is brought to us ready waſhed, and formed into large rolls or cylindric glebes, not of a chalky whiteneſs, but rather of an aſh colour. Formerly it came only from Tuſcany on the iſland Elva, at preſent it is ſupplied chiefly from Norway, the iſland of Bornholm, or places nearer home. It differs from the two preceeding, in containing no manifeſt irony matter, and conſequently in wanting their aſtringency. It has been recommended as an abſorbent, but experiments made upon it with Acids ſhew that it little deſerves that character, any more than the other Boles. Some have a method of recovering the luſtre of Pearls, eſpecially the Scotch ones, by warming them a little over the fire, and rubbing them with powdered white Bole.

Pearls cleaned.

White Bole examined by Acids, &c.

Out of ſixty grains of this kind of Bole, (1.) Spirit of Vitriol diſſolved four grains: The ſolution was

BOLE. was clear, and had ſcarce any vitriolic taſte; the reſiduum grey. (2.) Spirit of Nitre diſſolved ſix grains: Both the liquor and the reſiduum looked yellowiſh. (3.) Spirit of Salt, five grains: Both the Menſtruum and the Bole unaltered in colour. (4.) Diſtilled Vinegar, two grains: the liquor clear, the Bole unaltered. (5.) Citron juice, ſix grains: the ſolution taſted bitteriſh; the Earth looked ſomewhat darker. (6.) Rheniſh Wine took up nothing, but ſomewhat darkened the colour. (7.) Fixed Alcali was in part retained, as by the other Boles; increaſing the weight ten grains, or one ſixth. (8.) Spirit of Sal Ammoniac diſſolved three grains; the liquor appeared tinged a little; the Bole ſomewhat darker. (9.) Lime-water diſſolved two grains; the liquor clear, the Bole unchanged. (10.) Rectified Spirit of Wine diſſolved four grains, and left the Bole unaltered. (11.) Pure diſtilled water took up three grains; but the part diſſolved gradually fell down again, not in the form of powder, but what is pretty remarkable, in flakes reſembling a kind of mouldineſs.

Four ounces of white Bole yielded in diſtillation only one drachm and a half of a yellowiſh phlegmatic liquor, which ſmelt ſomewhat empyreumatic, and changed Syrup of Violets green: The Caput Mortuum was grey.

II. TRIPOLI.

TRIPOLI

Natural Hiſtory.

THIS Earth, brought perhaps at firſt from Tripoli in Barbary, is now found in ſeveral parts of Europe; in the iſland of Corſica, Iſchia, at Bayonne, in Spain, in ſeveral hills in France, particularly at Poligny near Rennes in Britanny, where it lies in Strata about a foot thick. It is always of a yellowiſh colour, commonly about the ſhade called an Iſabella yellow, ſometimes paler, ſometimes deeper, or variegated with darker ſtreaks inclining to reddiſh. The beſt ſort is ſoft, and eaſily rubbed, yet compact and

TRIPOLI Chemical Hiſtory.

and not very powdery, free from Sand or Gritt, of no taſte or ſmell, and not very heavy. It burns hard like the common potter's Earth, from which it differs little otherwiſe in quality, than in being more difficultly vitreſcible. Its principal uſe is for the poliſhing of metalline utenſils, optic glaſſes, *&c.* Some have employed it in the diſtillation of acid Spirits, but very unfrugally; common Loams and Brick earths being fitter for that purpoſe, as well as cheaper. Stahl made uſe of it in an ointment for the itch, which I prepared for him here, and which was compoſed of an Amalgam, ground firſt with as much Tripoli as rendered it pulverable, and then mixed with the camphorated white Ointment.

Two ounces of powdered Tripoli, diſtilled in a glaſs retort in an open fire, yielded at laſt two ſcruples of a weak Spirit of Salt; and in the neck of the retort was found a little blackiſh Sal Ammoniac. The reſiduum weighed four ſcruples leſs than at firſt. Mixed with Nitre, it extricated the Acid of that Salt, and gave over its own marine Acid; the diſtilled liquor proving an Aqua Regia, and diſſolving Gold. Out of ſixty grains of Tripoli, Oil of Vitriol diſſolved only one grain; Spirit of Vitriol, two; Spirit of Salt, three; Spirit of Nitre, five; and Aqua Regis, eleven. The ſolutions in the vitriolic and marine Acids were colourleſs: That in the nitrous, yellowiſh; and that made with Aqua Regis, of a deeper yellow, the Earth remaining white. Diſtilled Vinegar, and fixt and volatile Alcalies, had no effect: but the Cauſtic fixt Alcali diſſolved ſeven grains.

NEPHRITICUS.

Natural Hiſtory.

III. LAPIS NEPHRITICUS. (d.)

THE Lapis Nephriticus is a ſoft, brittle, opake Stone, not ſuſceptible of a good poliſh, ſmooth, and, as it were, unctuous to the touch, variegated with different colours, among which green is the principal. It is found in New and Old Spain, in Swiſſerland, Bohemia, and Saxony. From its imaginary medical virtues againſt nephritic diſorders, it has been ranked among the precious Stones; but in all

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(d) *Lapis Nephriticus.*] The Lapis Nephriticus is a ſpecies of the indurated Clays called from their unctuoſity, *Steatitæ*: With theſe it agrees, not only in its obvious properties, but likewiſe in its burning hard, the grand character of argillaceous Earths. Its green colour ſeems to proceed from copper: Pott relates, that on fuſion with an equal quantity of Borax, it yielded a beautiful red maſs, reſembling an agate, with a grain of Copper at the bottom. It is conſiderably the hardeſt of the ſubſtances of this claſs.

The Steatites, or Sope-rock, is ſaid to be plentiful in ſome parts of England, particularly in Cornwall. It is in general ſo ſoft as to be eaſily cut with a knife, and turned in a lathe. Among the Griſons in Swiſſerland, it is turned into pots for culinary uſes, by a pointed tool moved round by a mill; whence the ſtone is called *Lapis Ollaris.* It is ſaid that a great number of theſe veſſels are cut out of one maſs, with ſuch nicety, that they all fit exactly into one another again, and appear but one; that they are very durable; and that when cracked, they are joined by an Iron wire. The author above-mentioned obſerves, that childrens Marbles, and the China figures, are made of Steatitæ: and ſuſpects, that the heads, ſtatues, and other monuments of ancient artiſts, whoſe elegance, hardneſs, and durability are the admiration of ours, were cut from ſome of the ſoft ſteatitic Earths, which, after having freely yielded to the tool, and received the form, acquired from fire the hardneſs of Stones, and were finally embelliſhed with the poliſh which they ſtill retain. Thus much is certain, that the Steatite burn to a great degree of hardneſs, ſo as to ſtrike fire in abundance with Steel, and bear a fine poliſh; and that the ancients were well acquainted with theſe Stones and their properties. Theophraſtus expreſsly mentions a Stone found at Siphne, ſo ſoft as to be uſed by the ſculptor and turner, and cut into veſſels for the table, and which, when heated and impregnated with Oil, became very black and ſolid.

The greyiſh and pale greeniſh Steatitæ commonly burn white in an open fire, but in cloſe veſſels yellow: the yellow ſorts burn red, as participating of Iron, which, on digeſtion in Aqua Regis, is extracted, and tinges the menſtruum yellow. Thoſe which are naturally pure from Iron, or have been purified from it by Aqua Regia, melt with twice their weight of fixt Arſenic into a fine yellow Glaſs; and with equal their weight of Borax, into a greeniſh one, not ill reſembling the Beryl. With Clay they form a compound extremely hard, and of great whiteneſs. Theſe experiments were made by Mr. Pott on the Steatites of Bareuth in Franconia, there called *Schmeerſtein*, *Speckſtein*, *Meelbatz*; and by me, with the ſame ſucceſs, on the maſſes met with in the ſhops under the name of French Chalk, ſo called perhaps from their drawing white lines on cloth.

all its ſenſible qualities it is very far removed from thoſe of that claſs. It is ſurprizing that Hernandez, De Boot, and others, ſhould have referred it even to the Jaſpers, the Agates, or the Marbles; from all which it is extremely and obviouſly different: though it has the green ſpecks of the Jaſpers, it never has their red ones: it wants the hardneſs and compactneſs of thoſe Stones; and they, the unctuoſity or ſopineſs of the Nephritic. Profeſſor Nebel, in 1733, publiſhed a diſſertation on a new nephritic Stone: but this, from his own account of it, and the ſpecimen ſent me, appears to be an entirely different one; not having the green colour, the ſpecks, the ſopineſs, nor any of the characters of the Lapis Nephriticus. NEPHRITICUS.

Examined by Menſtrua. On examining the nephritic Stone by Menſtrua, nothing very remarkable was obſerved; except that a part of it was extracted by all Acids, and by ſome very conſiderable one. Out of ſixty grains, diſtilled Vinegar diſſolved three; Oil of Vitriol, ſeven; Spirit of Vitriol, fourteen; Spirit of Nitre, ſixteen; Aqua Regia, eighteen; and Spirit of Salt, twenty. The Spirit of Salt acquired a greeniſh yellow Tincture, Aqua Regia a Gold yellow; Oil of Vitriol a dark browniſh; the other Acids remained colourleſs. Both the marine Acid and Aqua Regia left the undiſſolved Earth whitiſh, the nitrous Acid greyiſh, the diluted vitriolic Acid browniſh yellow, the concentrated light reddiſh brown; the acetous, unchanged.

By diſtillation. An ounce of powdered Lapis Nephriticus, diſtilled in a retort in an open fire, yielded about a drachm and a half of phlegm, which had a penetrating empyreumatic ſmell, and made no change in the colour of Syrup of Violets. On diſtilling four ounces, I had an appearance of an actual empyreumatic Oil; with a ſaline matter, which was found to be Sal Ammoniac; for it efferveſced with Oil of Vitriol, and emitted fumes reſembling thoſe of Spirit of Salt, and with fixt Alcali it yielded urinous vapours. The matter remaining in the retort was of a reddiſh brown colour.

NEPHRITICUS. An ounce of the powdered Stone, mixed with an equal quantity of fixed alcaline Salt, and urged with a ſtrong fire, did not melt; but formed a quite porous maſs, in colour inclining to reddiſh grey, and weighing two drachms leſs than the mixture did at firſt.

CLASS V. TALKY EARTHS and STONES.

Earths, or ſoft ſtony concretes; — not acted on by any Acid; — and ſcarce calcinable by fire.

I. VENICE TALC.

TALC. Natural Hiſtory. VENICE Talc is a ſoft ſmooth concrete, unctuous or ſopy to the touch, of a whitiſh or pale greeniſh colour, with a Silver-like luſtre, generally found in ſmall pieces. It may be ſplit into numerous fine plates or leaves; which, ſingly, prove ſomewhat flexible and elaſtic, and perfectly pellucid, though the entire maſs is commonly opake, or at moſt only ſemi-tranſparent. The ſmalleſt pieces are to be preferred: the larger, however white and apparently pure on the outſide, being apt to have ſpecks or veins of heterogeneous matter in the internal part. This mineral has received the epithet Venetian, not from its being originally the product of Venice, but probably from that city having formerly been a principal mart for it. Though it may perhaps be met with in ſome parts of the Venetian dominions, it is more common in other countries; in Muſcovy, England, Norway, Hungary, Bohemia, Spain, and the Eaſtern nations.

Effect of fire on it. Talc is generally ſuppoſed to be entirely unſubduable by fire. But Mr. Boyle relates, that having kept ſome Venice Talc for a length of time in a glaſs-houſe furnace, it loſt of its volume, its compactneſs, and its luſtre, and became more brittle, though it ſtill retained the appearance which it had at firſt. I have myſelf alſo obſerved a like effect, the Talc, by ſtrong calcination, having loſt its luſtre and unctuoſity, though the diminution in weight was only one drachm upon ſix ounces: ſome white vapours aroſe in the calcination, reſembling thoſe of the Acid of Sea-Salt, but no ſpirit could be collected on repeating the operation in a retort; the Talc here loſt nothing of its weight, but had contracted a blackiſh hue. Morhoff, in his epiſtle to Langelot, on the tranſmutation of metals, declares, that he has ſeen Talc, in the ſpace of half an hour, and by a ſmall fire, calcined into a ſpongy maſs, friable betwixt the fingers into a ſubtile Powder. Charas has already queſtioned this experiment, and we may be certain it was not performed on any true Talc: probably the Lapis Specularis, or Selenites, were miſtaken for Talc; a ſuſpicion which is countenanced by the author's own words: he ſays the mineral was deprived of its yellow colour, a colour which thoſe Stones frequently have, but Venice Talc has not. Though Talc however in great meaſure reſiſts the action of culinary fire, I have found it incapable of reſiſting the concentrated ſolar heat: a piece of the true Venice Talc, expoſed to the focus of Tſchirnhaus's large burning lens, preſently melted into an untranſparent vitrious maſs.

Examined by Menſtrua.

I have examined Talc with all the mineral Acids, and with alcaline Lixivia, which ſome report to have a greater action on it; but without finding that either of them had any action at all; the Talc remaining undiminiſhed in weight, and neither the Talc or the liquors ſuffering any ſenſible alteration. I have calcined it alſo with Sulphur, and common Salt, with Nitre, with Sal Ammoniac; without any other effect than a little change in its colour. On trying to melt it with twice its weight of Borax, the Talc fell to the bottom as ſoon as the Borax came into fuſion. Alcaline Salts, and Cauſtic Alcalies, taken in four times the weight of the Talc, ſucceeded no better; this refractory Earth refuſing to

with fluxes

TALC. to unite with them: the Salts being afterwards deliquiated in the air, the addition of Acids occaſioned no precipitation, which they muſt have done if the Alcalies had taken up in fuſion any part of the Talc *(e)*.

Uſes. Talc is employed, in thoſe places where it is found in any conſiderable quantity, in compoſitions for earthen veſſels; and by ſome for teſts and cupels. From its ſmoothneſs, unctuoſity, and brightneſs, it has been greatly celebrated as a coſmetic; and the chemiſts have ſubmitted it to a variety of operations, for procuring from it Oils, Salts, Tinctures, Magiſteries, *&c.* for that intention. But all their labours have been in vain; and all the preparations ſold under the name of Talc have either contained nothing of that mineral, or only a fine powder of it. Oleum Tartari per deliquium, Vinegar of Litharge, Solution of Sugar, Oil of Almonds, or Oil of Ben with Sugar of Lead, have been put off under the ſpecious name of Oils of Talc. Otto Tachenius pretended the Terra foliata Tartari to be an artificial Talc; and accordingly vended, for Oil of Talc, a Solution of that Salt. Dr. Behms Ointment of Talc, which had a large run in Venice, I found to be no other than Pomatum mixed with a little powdered Talc.

(e) Vitreſcibility of Talc.] The author ſeems to have failed in theſe experiments from uſing too large a proportion of the Salts, and too weak a heat. Venice Talc, with half its weight of alcaline Salt, may, in a ſtrong fire, be brought into perfect fuſion, though not to perfect tranſparency: with equal its weight, or leſs, of Borax, it runs into a beautiful, pellucid, greeniſh yellow Glaſs. Talc does not melt with any other Earth, nor even bake or cohere with any but the argillaceous: Mixtures of it with them all are nevertheleſs brought into fuſion by a remarkably leſs quantity of ſaline matter than the ingredients ſeparately would require. Thus equal parts of Talc and Chalk, with only one fourth their weight of Borax, melt, in no very vehement fire, into a fine tranſparent, greeniſh Glaſs, of conſiderable hardneſs, and great luſtre. On ſubſtituting gypſeous Earths, as the Lapis Specularis, to Chalk, the fuſion was as eaſy, and the Glaſs as beautiful; in colour not green, but yellow, like the Topaz. Talc, with half its weight of Sand, and a quantity of Nitre equal to both, yielded alſo a tranſparent Topaz-yellow Glaſs. Several further experiments on Talc may be ſeen in a Memoir by Mr Pott *(Mem. de l'Acad. de Berlin,* 1746,*)* from which I have here inſerted only thoſe which I repeated myſelf, and which were all found fully to ſucceed.

TALC.

Pulverization.

The pulverization of this mineral is attended with ſome difficulty. The more brittle pieces may be pulverized pretty eaſily; but the very tough and flexible ſcarce at all; nor is heating the mortar and peſtle red hot, which ſome recommend, of any advantage. The moſt commodious method of reducing it into fine Powder is, by cautiouſly filing or grating it with a fiſh-ſkin.

II. SOLAR TALC.

SOLAR TALC.

BESIDES the white and greeniſh Talcs treated of in the foregoing article, there are yellow, red, and black foliaceous concretes diſtinguiſhed by the ſame name; but theſe are in general rather of the gypſeous than talky kind. Thus the black Talc, mentioned by Hoffmann, which laid on burning coals falls into leaves, and acquires a golden colour, ſeems to be a ſpecies of Lapis Specularis. Thoſe of a yellow colour have been called ſolar Talcs, and imagined to be impregnated with a ſulphur of Gold; which ſome of the chemiſts have pretended to extract by Spirit of Salt or Aqua Regis. But the yellow tincture which theſe minerals communicate, and the red ſublimate which ariſes on diſtilling the ſolutions, proceeds entirely from a ferrugineous matter, common to theſe with other coloured Earths.

III. AMIANTHUS.

AMIANTHUS.

AMIANTHUS and Aſbeſtus are ſtony concretes of the talky kind, though differing from Talc in their external appearance. They are not near ſo bright, or ſo ſmooth and unctuous; and are compoſed not of leaves or plates, but of long filaments like flax; whence they have been called Earth-flax, *Linum Aſbeſtinum.* They have been ſpun into Cloth, and formed into Paper, incombuſtible and indeſtructible in the fire (f).

IV. PUMICE.

PUMICE.

Natural History.

THE Pumice is a light very ſpongy Stone, rough to the touch, and eaſily rubbed into Powder. The beſt ſort is of a white or greyiſh colour: ſome have a yellowiſh, browniſh, or blackiſh tinge. Boccone mentions a red Pumice from Radicofani, but probably miſtook ſome other Stone for this. I have myſelf ſeen there abundance of reddiſh Stones, but no Pumice. The Pumice is found only about Volcanos, and appears to owe the form in which we meet with it, to ſtrong calcination by the ſubterraneous heat. It is thrown out from the Volcano, along with the fire and lava, in pieces of various figures and magnitudes, ſometimes pure, and ſometimes intermixed with the other matter. Sometimes it is taken up in the adjacent ſeas, and hence has been erroneouſly ſuppoſed by ſome to be a marine production; to be petrified ſponge, or the froth of the ſea coagulated and indurated with Sand or other ſubſtances. The whiteſt Pumices come from Ætna and Veſuvius. Hecla in Iceland affords more impure ſorts. PUMICE.

(f) *Incombuſtible Paper and Cloth.*] There are ſome ſorts of Aſbeſtos whoſe filaments are rigid and brittle; others more flexible. The firſt are not at all to be ſpun or formed into Cloth, and the latter very difficultly. This manufacture appears to have been known among the ancients, who according to Pliny wrapt the corpſe of the dead in aſbeſtine clothes to preſerve their aſhes ſeparate from thoſe of the funeral pile; an uſe to which they are ſtill ſaid to be applied among the princes of Tartary. The method of preparation, as deſcribed by Ciampini in the Philoſophical Tranſactions, No. 273, is as follows. The Stone is laid to ſoak in warm water, then opened and divided by the hands, that the earthy matter may be waſhed out. This Earth is white like Chalk, and renders the water thick and milky. The ablution being ſeveral times repeated, the flax-like filaments are collected and dried: they are moſt commodiouſly ſpun with an addition of Flax. Two or three filaments of the Aſbeſtos are eaſily twiſted along with the Flaxen-thread, if the operator's fingers are kept oiled. The Cloth alſo when woven is beſt preſerved by Oil from breaking or waſting. On expoſure to the fire, the Flax and Oil burn out, and the Cloth comes out pure and white. Probably from the diſſipation of ſome extraneous matter of this kind proceeded the diminution of weight which an aſbeſtine napkin ſuffered in the fire, in an experiment made before the Royal Society; for pure Aſbeſtos loſes nothing. — The ſhorter filaments, which ſeparate in waſhing the Stone, may be made into Paper in the common manner.

Pumice Stone is ſaid by Ettmuller to be an alcaline abſorbent. A part of it is indeed diſſolved or extracted by Acids: out of thirty grains of the powdered Stone, Oil of Vitriol diſſolved ſix grains, Spirit of Vitriol ten, Spirit of Nitre nine, Spirit of Salt and Aqua Regis each eleven, and diſtilled Vinegar ten: But all the liquors retained their acidity as ſtrong as if they had taken up nothing from the Pumice; nor did they raiſe with it any effervеſcence. It is acted on more powerfully by Alcalies themſelves than by Acids. Fixed alcaline Lixivia diſſolved fifteen grains out of thirty; and volatile Spirits twelve grains. Examined by Acids.

The Solutions in Acids are all colourleſs; except that made with the vitriolic, which inclines to yellow. The author above-mentioned relates, that diſtilled Vinegar extracts from Pumice a greeniſh tincture; and hence ſuſpects that this Stone is impregnated with Copper. I have never obſerved the ſlighteſt green tincture, but from ſuch as had been pulverized in a braſs mortar.

Sixteen ounces of Pumice, diſtilled in a retort, yielded an acid liquor, and a viſible empyreumatic Oil, of an extremely ſtrong ſmell, amounting both together to half an ounce and one ſcruple. In the neck of the retort was found about a ſcruple of true Sal Ammoniac, of a browniſh-grey colour. The reſiduum appeared of a blackiſh grey, and weighed about fifteen ounces. Half an ounce, calcined in a crucible, in an open fire, loſt a ſcruple, or one twelfth. By diſtillation.

The principal uſe of Pumice is in mechanic buſineſſes, for ſcouring, cleaning, and poliſhing metals, leather, *&c.* It is ſometimes alſo employed in dentifrices. The pumice Powder with which Gold has been poliſhed, as retaining ſome particles of that metal, is ſaid by the author of *Sol ſine veſte* to afford a ruby Glaſs. Uſes.

SECT. II.

METALLIC BODIES.

METALS Diſtinguiſhing characters of Metals, and Semimetals;

METALLIC Bodies are divided into *Metals*, or thoſe which are capable of being worked and conſiderably extended under the hammer; and *Semi-metals*, or thoſe which want that valuable quality. There are other characters alſo, no leſs diſcriminitive of the two claſſes: Metals appear when broke of an uniform, or a fibrous, or a granulated texture; whilſt the broken ſurfaces of Semimetals (the fluid one, Quick-ſilver, excluded) are compoſed of large angular plates or flakes: Metals, expoſed to the moſt intenſe degree of culinary fire, if the air is perfectly ſhut out, remain fixed and unaltered at the bottom of the veſſel; whilſt Semimetals, impatient of vehement heat, ariſe in fumes into that part of the veſſel which is furtheſt removed from the fire, and there condenſe again into their original form.

Of perfect and imperfect Metallic Bodies.

Though neither Metals or Semi-metals ſuffer any eſſential change from heat, ſo long as the air is excluded; there are ſeveral bodies of both claſſes, which, by the action of fire and air conjointly, are gradually deprived of their metallic appearance and qualities, and converted into a powdery or vitreous ſubſtance, called *Calx* or *Scoria.* Hence ariſes a further diſtribution, into *Imperfect*, or thoſe which are ſuſceptible of theſe changes; and *Perfect*, or thoſe which ſuffer none.

CLASS

CLASS I. PERFECT METALS.

Malleable Metals; — not calcining in the fire, either by themſelves, or with the addition of Nitre, or of Lead, which haſten the deſtruction or calcination of the imperfect; — when corroded by Acids into the appearance of a Calx, recoverable again in their priſtine form, without addition, or with only ſuch additions as may abſorb the Acid.

I. GOLD.

Gold. Its general properties, Ductility.

GOLD (the *Sol*, and *Rex metallorum*, of the chemiſts) is a yellow metal ſcarce at all elaſtic or ſonorous, very ſoft and flexible, the moſt ductile of all metallic bodies. Dr. Halley took one grain of gilt Silver, of which only one forty-eighth part was Gold. This grain was drawn into a wire two ells in length, which, examined by a microſcope, appeared every-where covered with the Gold. A piece of the wire being put into Aqua fortis, the Silver was eaten out, and a tube of Gold remained, which, notwithſtanding its extreme thinneſs, was ſtill opake.

Gravity.

Gold is of all natural bodies the moſt ponderous: hence it ſinks in Quick-ſilver, whilſt all other ſubſtances [Platina excepted] ſwim on the ſurface. It is upwards of nineteen times heavier than an equal bulk of water. A Paris cubic foot is reckoned to weigh 1368 pounds *(a)*. From its greater denſity it becomes ſenſibly hotter than other bodies when laid along with them in hot water.

Fuſibility.

Gold melts in a red heat, much ſooner than Copper or Iron; though much later than Lead or Tin *(b)*.

It

(a) Gold — Gravity.] The proportional gravity of Gold to water has been reported to be as 19,640 to 1: Mr. Browal, in the Swediſh Tranſactions, makes it no leſs than 20. In ſundry trials, with different pieces of fineſt Gold I have been able to procure, the gravity turned out between 19,280, and 19,290.

(b) Gold — in the fire.] Gold requires for its fuſion a ſtrong red, or a low degree of white heat, a little greater than that in which

Silver

GOLD.

Fixity,

It is of all metals the moſt fixed or permanent in the fire. An ounce has been kept for two months together, in a glaſs houſe furnace, which, of all furnaces, gives the moſt vehement heat, without ſuffering the leaſt diminution of its weight. Homberg relates,

Expoſed to a burning-glaſs.

that in the focus of Tſcirnhaus's large burning-glaſs, it loſt its fixity; that it ſmoked, diminiſhed in volume, changed into a red Earth, and at laſt even vitrified. But as the Gold had been placed on a piece of Charcoal, the vitreous matter probably proceeded from the aſhes of the coal. Mr. Geoffrey often aſſured me, whilſt we were making experiments together with the ſame burning lens, that no ſuch vitrification had been obſerved, when any thing beſides charcoal was uſed for the ſupport.

Solution.

Gold diſſolves in a mixture of the nitrous and marine Acids, called, from its action on this *Rex Metallorum*, Aqua Regia. Either of thoſe Acids ſingly have no effect upon it; nor is it acted on by the vitriolic. Boerhaave ſays, that Sea-Salt or Sal Gem are the only menſtrua of Gold; and that both theſe Salts diſſolve it, whether applied in the form of a Lixivium or Spirit. Experience affords no foundation for this aſſertion (*c*). The ſolution in Aqua

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Silver melts. Whilſt fluid, it appears of a bluiſh green colour: when grown cold, its ſurface looks bright, ſmooth, and conſiderably concave. It ſeems to expand more in the act of fuſion, and to ſhrink more in its return to ſolidity, than any of the other metals; whence the greater the concavity of its ſurface. Before fuſion, it expands the leaſt of any except Iron. By ſudden cooling, it becomes, as the other metals, brittle; an effect, which has been, in general, erroneouſly attributed to the contact of fuel during fuſion.

With other Metals.] Gold amalgamates very readily with Mercury, and mingles in fuſion with all the metals. It is remarkably diſpoſed to unite with Iron; of which it diſſolves many times its own weight, in a heat not much greater than that in which Gold by itſelf melts: the mixture is of a ſilver colour, very brittle, and hard. All the metals, except Copper, debaſe the colour of Gold; and if their quantity is nearly equal to that of the Gold, almoſt entirely conceal it. All but Copper and Silver deſtroy its malleability; none ſo remarkably as Tin and Lead: A moſt minute portion, even the vapour, of theſe renders Gold extremely brittle; though a ſmall proportion of Gold forms with them compounds ſufficiently ductile, more ſo than either the Lead or Tin by themſelves.

(*c*) *Solubility in Acids.*] Gold is commonly ſuppoſed incapable of being diſſolved in any ſimple Acid. It appears however to be ſoluble, in

GOLD.

Aqua Regis is of a Gold yellow colour, and ſtains the ſkin, where-ever it touches, of a fine purpliſh red, which is not eaſily got off.

changes of its properties by art,

Singular and unalterable as the properties of Gold appear to be, they are eaſily maſtered by chemiſtry. A ſingle grain of Tin will deſtroy the ductility of a thouſand grains of Gold; rendering the moſt malleable Gold not only incapable of being extended, but of bearing the hammer at all. In Kunckel's *Laboratorium Chymicum*, there are proceſſes by which Gold may be ſublimed and diſtilled over the helm; and ſurely what ſublimes or diſtils has loſt its fixity. Mercury-ſublimate and Sal Ammoniac volatilize

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in certain circumſtances, both by the nitrous and marine, though not ſo readily or plentifully as by a mixture of them.

Dr. Brandt produced before the Swediſh academy of ſciences a ſolution of it in the nitrous Acid, obtained in parting, by that Acid, a mixture of Gold and Silver. The mixed metal was boiled with Aqua fortis in a glaſs body fitted with a head and receiver, the liquor poured off, and the coction repeated with freſh parcels of ſtronger and ſtronger nitrous ſpirits, till all the Silver was judged to be extracted. The laſt parcel was boiled down till the matter at the bottom looked like a dry ſalt; on boiling this in freſh Aqua fortis, in cloſe veſſels as before, a part of the Gold was diſſolved, and the liquor tinged yellow. See the Swediſh Tranſactions for the year 1748. But though Gold is by this means truly diſſoluble in the nitrous Acid, the union betwixt them is extremely ſlight; the Gold being not only precipitated on the addition of Silver, or ſuch other metals as diſſolve in that Acid, but likewiſe ſubſiding ſpontaneouſly upon expoſure to the air.

The marine Acid has no action on Gold in its metallic ſtate, in whatever manner the Acid be applied: but if the metal is previouſly attenuated, or reduced into the form of a Calx, either by precipitation from other Menſtrua, or by calcination in mixture with calcinable metals, this Acid will then perfectly diſſolve, and keep it permanently ſuſpended. Gold is precipitated from Aqua Regis by fixed Alcalies, and edulcorated by ablutions with boiling water, I have diſſolved even in a very weak Spirit of Salt by moderate digeſtion. This ſolution appears of the ſame yellow colour, as that made in Aqua Regis: it gives the ſame purple ſtain to the ſkin, feathers, bones, and other ſolid parts of animals; the ſame violet ſtain to Marble; and ſtrikes the ſame red colour with Tin. Even when common Aqua Regia is made uſe of for the menſtruum, it ſeems to be chiefly by the marine Acid in that compound liquor, that the Gold is held in ſolution. In diſtillation, it is the nitrous Acid which ariſes; and the marine which remains combined with the Gold into a blood-red maſs, ſoluble, like the combinations of moſt metallic bodies with that Acid, in Spirit of Wine.

it (*d*). There is a certain common and well known ſubject, plentifully made uſe of by every body, which robs Gold of its luſtre, its colour, and its malleability, and renders it white and brittle: but this ſubſtance, as it might give riſe to abuſes, I forbear to name. Gold melted repeatedly with Borax, becomes paler and paler on every fuſion; and there are ſundry other ſubſtances, as Butter of Antimony, Zinc, and the ſmoking Spirit of Tin, from which it ſuffers notable alterations. After all theſe changes however, it is ſtill reducible to its original ſtate: the brittle, the white, the ſublimed, the diſtilled Gold, may all be reſtored to the purity and properties of the Gold at firſt. The chemiſts have long laboured in the deſtruction of this metal, and allow it to be eaſier to make Gold than to deſtroy it; though it does not appear, that either of theſe problems is entirely beyond the reach of art: for a little Gold has in divers experiments been produced; and Gold was deſtroyed in the preſence of Mr. Boyle (*e*).

whether deſtructible or producible.

Aqua

(*d*) *Volatilization of Gold.*] The volatilization of Gold, though it has been looked upon as one of the proceſſes of the ſublimer metallurgy, may be effected without difficulty. If a ſolution of Gold in common Aqua Regia be inſpiſſated, the reſiduum diſſolved in freſh Aqua Regis, and the liquor diſtilled off: upon haſtily increaſing the fire towards the end of the operation, part of the Gold diſtils in form of a high Saffron-coloured liquor, and part ſublimes into the neck of the retort, in cluſters of long ſlender Cryſtals, of a deep red colour, fuſible in a ſmall heat, eaſily ſoluble in water, and deliquiating in the air. By repetitions of the proceſs, the whole quantity of the Gold may thus be elevated, excepting a ſmall proportion of white Powder, whoſe nature and qualities may deſerve further examination.

(*e*) *Boyle's degradation of Gold.*] The experiment, here referred to, is a very curious and extraordinary one, though it falls ſhort of proving the deſtructibility of Gold. About one eighth part of a grain of Powder communicated by a ſtranger, was projected upon two drachms of fine Gold in fuſion, and the matter kept melted about a quarter of an hour. During the fuſion, the metal looked like ordinary Gold: when cold, it appeared of a dirty colour, and as it were overcaſt with a thin coat almoſt like half vitrified litharge: The bottom of the crucible was overlaid with a vitrified ſubſtance, partly yellow, and partly reddiſh brown; with a few ſmall globules, more like impure Silver than Gold. The metal was brittle, internally like Braſs or Bell-metal, on the touchſtone more like Silver than Gold: Its ſpecific gravity was to that of water only as $15\frac{2}{3}$ to 1. There was no loſs of weight.

Though

Aqua Regia, the proper menſtruum of Gold, is commonly prepared by diſſolving one part of Sal Ammoniac in four of Aqua fortis or Spirit of Nitre. Kunckel directs a commodious method of obtaining the exact proportions neceſſary for the ſolution: the Gold, either in form of leaves, or granulated, or flatted into thin plates, then made red hot and cut in ſmall pieces, is to be put into a ſuitable quantity of Aqua fortis, a gentle heat applied, and ſome powdered Sal Ammoniac added gradually, by little and little at a time, till the whole of the Gold is diſſolved *(f)*.

Commodious method of diſſolving it,

There are, beſides this, ſome uncommon and curious ſolutions of Gold, as the ſulphureous one, which was diſcovered by Stahl, and publiſhed in his tract *de vitulo aureo (g)*. Langelot contrived a machine, which

ſoluble by ſulphur,

Though the Gold was ſurprizingly altered in this experiment, it was not deſtroyed: Mr. Boyle himſelf informs us, that ſixty grains of the maſs yielded on cupellation fifty-three grains of pure Gold; with ſeven grains of a fixed, ponderous, dark coloured ſubſtance: and probably this laſt, by proper treatment, might likewiſe have been reduced into Gold again.

(f) Kunckel's method of diſſolving Gold.] By this method a much ſmaller quantity of the menſtruum proves ſufficient, than if the Sal Ammoniac was previouſly diſſolved in the Aqua fortis; the conflict, which each addition to the Salt raiſes with the Acid, greatly promoting the diſſolution of the Gold. Aqua fortis of moderate ſtrength will thus take up about one third its weight of Gold; whereas an Aqua Regis, ready prepared from the ſame Aqua fortis, will not diſſolve above one fifth its weight. Sea-Salt, managed in the ſame manner, anſwers better than Sal Ammoniac.

(g) Stahl's ſulphureous ſolution of Gold.] Gold is not acted upon in the leaſt by pure Sulphur; which ſcorifies or diſſolves in fuſion every other metallic body, except Zinc and Platina. But if the Sulphur be previouſly melted with an equal quantity of fixed alcaline Salt; this compound, melted with Gold, readily unites with it into an uniform maſs, which diſſolves in water without any ſeparation of the Gold. The author above mentioned endeavours to prove, that ſulphurated Alcali was the medium by which Moſes calcined the golden calf ſo as to be miſcible with water. The ſolution, beſides a nauſeous taſte from the Sulphur, has a peculiar penetrating bitterneſs, not diſcoverable in any other metallic ſolution made by the ſame means.

Though the compoſitions of Sulphur and Alcali ſeem to unite more intimately with Gold than with other metals, their affinity with it is but ſlight: Copper or Iron, added to the matter in fuſion, diſunite and precipitate the Gold. The Gold, thus recovered, and purified by the common proceſſes, proves remarkably paler coloured than at firſt. In an experiment related by Dr. Brandt in the Swediſh Memoirs, the purified Gold turned out nearly as pale as Silver, without any diminution of its weight.

which he calls the philoſophic mill; in which Leaf-gold was ground with water to ſuch a degree of tenuity, as to paſs along with the water through the pores of a filter: This however is no true ſolution, the Gold being here barely divided into minute atoms, which on ſtanding ſubſide again from the water by their own gravity. When Gold is triturated for a length of time in a glaſs mortar, a little vitreſcible matter is obtained: this does not proceed, as ſome have ſuppoſed, from the Gold, but from a portion of the matter of the Glaſs rubbed off in the grinding.

insipid Menſtrua for Gold.

Much has been talked of inſipid menſtrua for Gold. Hoffman looks upon all theſe as matter of fiction, or of fraud; and queſtions the exiſtence of any ſubject in nature, from which ſuch a menſtruum could be prepared. Thus much however is certain, that if Gold be put into a receiver with ſome plain water, and a Glaſs body, containing a certain liquor, be fitted with a head joined to the receiver; and the whole ſuffered to ſtand in the cold, the Gold will, by degrees, imperceptibly diſſolve in the water. Kunckel relates, that Gold may be diſſolved by placing it in a receiver with Spirit of Wine, and driving over Spirit of Nitre upon it, or by putting the Gold into Spirit of Salt, and adding ſome drops of Spirit of Urine. Neither of theſe experiments ſucceeded with me; though Kunckel rarely advances any thing as fact, that is not really ſo (*b*).

Reputed Menſtrua.

Aurum Fulminans

From the ſolution of Gold in Aqua Regis is prepared the clay-like Precipitate, called, from its exploſive power, *Aurum Fulminans*. The ſolution is diluted with water; and either a fixt alcaline Lixivium, or a volatile alcaline Spirit, gradually added, or the fixt and volatile Alcali dropt in alternately,

till

(*b*) *Reputed Menſtrua for Gold.*] I have likewiſe tried theſe liquors, and the mixtures of vitriolic Acid with Salt of Tartar and with urinous Spirits, ſaid by the ſame author to be menſtrua for Gold, without ſucceſs. Mr. Pott informs us, in a paper in the Berlin Memoirs for the year 1752, that he obtained a ſpirit which diſſolved Gold, by diſtilling a ſolution of the ſecret Sal Ammoniac (that is, a neutral Salt compoſed of volatile Alcali and Oil of Vitriol) made in twice or thrice its quantity of Aqua fortis.

till the precipitation is completed. The Precipitate obtained by volatile Alcalies is in leſs quantity than by the fixed, but fulminates more ſtrongly *(i)*. This preparation is to be tried with the utmoſt caution: it explodes from being barely ſet in a warm place, or moderately rubbed in a mortar, and its exploſion is extremely violent, ſo as to have been too often productive of terrible effects; of which examples may be ſeen in the *Ephemerides naturæ curioſorum*, and in the Breſlau Collections. It is commonly ſuppoſed to exert its action only downwards, but it acts equally in all directions, though its effect is moſt conſpicuous on the ſolid body upon which it is placed. The report is preceded by a flaſh, viſible in the dark; and, during the exploſion, the Gold is revived into little granules, which may be caught by means of proper veſſels, as I ſhewed to ſeveral members of the Royal Society in London, and as Kunckel alſo has obſerved. The fulmination appears to proceed, not from the Gold, but from a ſubtile ammoniacal Nitre, or *Nitrum flammans*, compoſed of the nitrous Acid and volatile Alcali: a Precipitate made without volatile Alcali, either in the menſtruum or precipitant, will not fulminate: if to ſuch as does fulminate we add vitriolic Acid, which abſorbs the volatile Alcali from the nitrous, its fulminating quality will be deſtroyed: ſaturated afreſh with volatile Alcali, it recovers its exploſive power. That Gold is not neceſſary to the fulmination, appears from the effect

cauſe of its fulmination.

(i) Precipitation of Gold by Alcalies.] When fixed Alcalies are made uſe of, the Precipitate weighs about one fourth more than the Gold employed. With volatile Alcalies alſo, if they are cautiouſly added in no larger proportion than is ſufficient to ſaturate the Acid, the quantity of Precipitate proves nearly the ſame: but if the volatile Spirit is added in an over-proportion, it rediſſolves a part of the Gold which it had before precipitated, and the liquor becomes again conſiderably yellow. I could not, however, by any addition of the ſpirit, procure a total rediſſolution of the Gold, though both the animal oily Spirits, and that of Sal Ammoniac, prepared both with Salt of Tartar and with Quick-lime, were made trial of: nor did either of theſe ſpirits ſenſibly diſſolve, or extract any tinge from precipitates of Gold which had been thoroughly edulcorated with boiling water.

of the *pulvis fulminans* and other fulminating preparations in which there is no Gold.

Some prepare their Aurum Fulminans [of a purple colour] by evaporating the ſolution of Gold to dryneſs, diſſolving the dry matter in freſh Aqua Regia, inſpiſſating the liquor again, and repeating this procedure a ſecond and a third time: the ſolution is at laſt evaporated to the conſiſtence of Oil, and then precipitated with Oil of Tartar per deliquium. This method is not to be approved; as we can ſeldom, from ſuch thick liquors, obtain a complete precipitation.

Precipitations of Gold.

Ruby Glaſs,

Solution of Gold may be precipitated by ſundry ſubſtances beſides Alcalies; as Quick-ſilver, ſolution of Quick-ſilver, ſolution of Vitriol, ſolution of Verdigris, Tin, *&c.* *(k)* — Solution of Tin, dropt into a ſolution of Gold largely diluted with water, or Tin itſelf added to the diluted liquor, changes its yellow colour to a fine purpliſh red *(l)*. By this mark, minute portions of Gold may be diſcovered in liquors. The Precipitate, which ſubſides on ſtanding, is likewiſe of a purpliſh red; and, melted with a large proportion of fritt or colourleſs Glaſs, tinges it of a beautiful red colour: Kunckel obſerves, that one part of Gold is ſufficient to communicate a ruby red to twelve hundred and eighty parts of Glaſs, and a ſenſible redneſs to nineteen hundred and twenty *(m)*. If ſolution of Gold made in Aqua Regis be evaporated a little, ſome rectified Spirit of Wine added, and the whole ſuffered to remain quiet, the Gold will ſhoot into Cryſtals.

(k) *Precipitation of Gold by metallic ſubſtances.*] All the metallic bodies which diſſolve in Aqua Regia, Platina excepted, precipitate Gold from it. Mercury and Copper throw down the Gold in its bright metallic form; the others, in that of a Calx or Powder which has no metallic aſpect.

Iron combined with the vitriolic Acid, that is, Vitriol of Iron, though it continues a precipitant for Gold, precipitates no metallic body beſides; and hence we are furniſhed with a commodious method of purifying Gold from admixtures of all other metals. Kunckel directs Vitriol of Copper for this purpoſe, having propably made the experiment with a mixed Vitriol participating both of Copper and Iron, and attributed to one ingredient what was effected by the other: no Vitriol but that of Iron makes any precipitation in ſolution of Gold.

(l) *Purple or red with Tin.*] This phœnomenon ſucceeds with certainty when Tin in ſubſtance is uſed, provided the ſolution of Gold be largely diluted with water: with ſolution of Tin we cannot ſo eaſily ſecure ſucceſs, either in regard to the colour or precipitation. — It is obſervable, that though the Gold is here precipitated by Tin from the diluted ſolution; yet if the whole be ſuffered to ſtand till the water has in a great meaſure exhaled, the Gold is taken up afreſh, the liquor becomes yellow as at firſt, and only a white Calx of Tin remains,

Cryſtals of Gold.

(m) Ruby Glaſs.] The art of tinging Glaſs throughout of a ruby colour was diſcovered ſince the middle of the laſt century by Dr. Caſſius: the red glaſſes of earlier date are only ſuperficially painted. Kunckel was the firſt who brought the proceſs to any conſiderable perfection; and, as he informs us himſelf, prepared the Glaſs in large quantity, and vended it at a great price: He ſays he made a chalice of it for the elector of Cologn, of an uniform fine colour throughout, weighing no leſs than twenty-four pounds.

All that we can collect from his writings, relating to the proceſs, is, that he uſed for the tinging ingredient the Precipitate of Gold made with Tin; that this colours a large quantity of Glaſs, as above mentioned; that the proceſs does not conſtantly ſucceed; that oftentimes the Glaſs comes out of the pot colourleſs as Cryſtal, and receives its redneſs on being expoſed to a ſmoky flame; that Nitre or Sal Ammoniac, added to it in fuſion, call forth its latent colour; and that the colour thus extricated by the latter is the moſt beautiful, but quickly diſappears again upon continuing the fire. From the experiments of Orſchal, in a treatiſe entitled *Sol ſine veſte*, it appears, that other preparations of Gold, even the muddy matter obtained in poliſhing Gold with Pumice, anſwer equally with the Precipitate by Tin.

One Grummet, who had been an operator to Kunckel, publiſhed a tract in oppoſition to the foregoing, under the title of *Sol non ſine veſte*; in which he endeavours to prove, by experiments, that the Gold has no ſhare in the production of the colour, and that this proceeds wholly from Manganeſe employed in the compoſition of the Glaſs. He affirms that if white or Venice Glaſs, (in the making of which, a proportion of Manganeſe is uſed, for promoting the tranſparency,) be reduced into powder, and melted with one fourth or one eighth of Nitre, it will acquire the true ruby colour; and that no addition of Nitre or of Gold will communicate any thing of that colour to a Glaſs made from Alcali and Flint without Manganeſe.

Thus much is certain, that Glaſs may be tinged of a fine red colour by means of Manganeſe; that this colour totally diſappears upon a continuance of the fuſion; and may be again brought back by an addition of Nitre.

In regard to Gold, with its calx precipitated by Tin, I have, in the glaſs-houſe furnace, tinged common white Glaſs of a true ruby red. With fritts compoſed of calcined Flint and alcaline Salt or Borax, melted with the ſame calx in a wind furnace, the colour did not equally ſucceed, though the proceſs was upwards of twenty times repeated and varied; and Sal Ammoniac, Nitre, and ſmoky flames, were called in aid: the Glaſs proved commonly yellowiſh, with violet coloured veins: ſometimes there were ruby-coloured ſpecks, and generally a button of revived Gold at the bottom.

GOLD.

Of Gold as a medicine

Gold has been imagined to be poſſeſſed of extraordinary medicinal virtues; and many preparations, dignified with the name of this precious metal, have been impoſed upon the public. But the virtues aſcribed to Gold have apparently no other foundation than credulity and ſuperſtition: and moſt of the golden medicines have no Gold in them: Even when Gold has been employed in the preparation, there is ſeldom any of it retained in the product. We may ſay with Ludovici, "It is better to make Gold out "of medicines, than medicines out of Gold."

Of extracting its tinging matter.

Some have pretended to extract the tinging matter of Gold, ſo as to leave the body of the metal white; miſled either by employing a menſtruum, which of itſelf acquired a colour during the digeſtion; or by finding at the bottom of the Glaſs, or on the ſurface of the Gold, a little white matter, which was no other than Silver previouſly contained in the Gold, or Regulus of Antimony with which the menſtruum had been impregnated: it was by uſing ſuch a menſtruum (the bezoardic Spirit of Nitre, as it is called) that Mr. Boyle was deceived *(n)*.

Tinctures.

Hoffman, the elder Geoffroy and others, prepare tinctures of Gold by Spirit of Wine and eſſential Oils, from a ſolution of the metal made in Aqua Regis: ſome take the *Oleum vini*, or a well made *Spiritus*

(n) Boyle's white metal from Gold.] Mr. Boyle relates, that on diſſolving fine Gold in an Aqua Regia diſtilled from Butter of Antimony and Aqua fortis, a conſiderable quantity of white powder remained undiſſolved: that the Gold, being reduced into a body, yielded on a ſecond ſolution more of this powder, but in leſs quantity than the firſt time: that with common good Aqua regia, he could obtain, from the very beſt Gold, ſome little quantity of the like white powder: And that theſe powders, melted with Borax, gave a white malleable metal, whoſe appearance, ſolubility in Aqua fortis, and odious bitterneſs when diſſolved, ſhewed to be true Silver.

We cannot ſuppoſe, as ſome have done, that this metal proceeded from an antimonial Regulus contained in the menſtruum; any more than, with Mr. Boyle, that it was a part of the Gold actually tranſmuted into Silver. It is by quartation with Silver (ſee page 43.) that Gold is commonly refined; and in that proceſs it always retains a portion of the Silver, ſeparable by Aqua Regia. When Aqua Regia is made with an under proportion of marine Acid, it diſſolves a little Silver along with Gold; and hence probably the Silver obtained on the ſecond diſſolution.

Spiritus vitrioli dulcis: but all theſe preparations receive their virtues from the additional matters, and not from the Gold. It is obſervable, however, that Oil of Juniper-berries, and perhaps other eſſential Oils, mixed with a ſolution of Gold in Aqua Regis, take up the Gold from the Acid, and acquire commonly a blackiſh colour on the upper ſurface, and a Gold-yellow one underneath *(o)*: If this mixture is ſet to digeſt, we muſt be cautious in regard to the fire, for it is apt to grow ſuddenly hot, and at once run over the veſſel. Hoffman ſays, how juſtly I pretend not to determine, that the beſt preparation of Gold for medicinal uſe, is a mixture of two parts of martial Regulus of Antimony and one of Gold melted together, and calcined in a glaſs phial till they are changed into a purple crocus.

Gold taken up from Aqua Regis by Oils.

The largeſt quantities of Gold are met with in the Spaniſh Weſt Indies. There are mines of it alſo in ſome parts of Europe, particularly in Hungary and Tranſylvania. It is either imbedded in flinty or other ſtones, or intermingled among the looſe earth; always in its metallic form, though the particles are commonly very ſmall and often indiſtinguiſhable *(p)*. It is never found in the ſtate of a true ore,

Natural hiſtory of Gold.

(o) *Gold taken up from Aqua Regia by eſſential Oils.*] The Gold, thus imbibed by Oils, does not long remain diſſolved in them; in a few hours it ſeparates, in bright yellow films, to the ſides of the Glaſs. — The ſubtile oily fluid called Æther or æthereal Spirit of Wine, takes up the Gold more readily and perfectly than the common Oils, and keeps it permanently diſſolved, the acid liquor underneath appearing colourleſs: the yellow æthereal ſolution, carefully poured off, and kept for ſome time in a glaſs ſtopt with cork ſo as that the ſpirit may ſlowly exhale, yields long, priſmatic, tranſparent Cryſtals, in ſhape like thoſe of Nitre, in colour yellow like Topaz. —— Rectified Spirit of Wine mingles uniformly with the ſolution of Gold made in acids: If the mixture is ſuffered to ſtand for ſome days in a glaſs ſlightly covered, the Gold is by degrees revived, and ariſes in bright pellicles to the ſurface. — Groſſer inflammable matters, Wine, Vinegar, Solutions of Tartar, throw down the Gold, in its metallic form, to the bottom. —— Gold is the only metallic body which is thus ſeparable from its ſolutions in Acids by either of theſe ſubſtances: and hence Gold may by theſe means be purified from all admixtures, and ſmall proportions of it in liquors readily diſcovered.

(p) *Gold in Stones, Ores, &c.*] There are two general methods of extracting Gold from its ore or matrix; amalgamation and fuſion.

1. When

GOLD. ore, unleſs when blended with a large proportion of other metals. The Gold ore of Rammelſberg in Goſlar holds only a few grains on an hundred weight. Some

1. When the Gold is ſuperficially embedded in earths or ſtones, in in its metallic form, the mineral is reduced into powder, the lighter earthy parts ſeparated by ablution with water, and the remainder triturated with a quantity of Quickſilver; which imbibes or amalgamates with the Gold, whilſt the earthy and ſtony matters float on the ſurface, and are eaſily waſhed off: the waſhed Amalgam being committed to diſtillation, the Mercury ariſes, and the Gold is left behind. This is the method by which Gold and Silver are extracted from their ores in the Spaniſh Weſt-Indies.

2. When the Gold is too intimately combined in the compoſition of the ore, to be ſeparable by Quickſilver, the mineral is brought into fuſion by fire. If the quantity of Gold was very conſiderable, it would ſubſide from the fluid matter by its own gravity, by whatever means the fuſion was procured: but in ores, the Gold is in too ſmall proportion, its particles too minute and too widely diffuſed, to ſeparate in this manner, without the addition of ſome other metallic body to imbibe and collect it. The addition commonly made uſe of is Lead; this metal eaſily vitrifying in the fire; and, when vitrified, powerfully promoting the vitrification or fuſion of earthy or ſtony matters; at the ſame time that the part which remains unvitrified imbibes the Gold and carries it to the bottom. Biſmuth anſwers the ſame end, rather more effectually; its Glaſs being ſomewhat more active as a flux than that of Lead, in regard both to the facility and tenuity of the fuſion. The Gold thus transferred into Lead or Biſmuth, is ſeparated by keeping the mixture in fuſion upon a cupel or teſt. The cupel is a ſmall ſhallow veſſel made of bone-aſh, which abſorbs the Lead or Biſmuth, in proportion as they vitrify. The teſt is a large oval hearth, on which the Lead, as it vitrifies and ariſes to the ſurface, is raked off from the Gold, or blown off by bellows.

Minerals containing Gold intimately blended in their compoſition are frequent in moſt parts of the world. Many of our common ſands are perhaps richer in this metal than the ores of Peru; though they yield it with ſuch difficulty, that it is ſcarce to be extracted from them to any advantage. The yellow, red, black, ferrugineous ſands are the richeſt, but at the ſame time the moſt refractory; the matter being not only very hard of fuſion, but the Gold ſtrongly retained, and defended from the action of Lead, by the ferrugineous part. Becher formed ſome expectations from ſome experiments on the more fuſible Sands; which, though they hold leſs Gold, yield it with more eaſe.

Mr. Hellot informs us, (in his French verſion of Schluter) that in eleven eſſays of the ſame ferrugineous ſand, made by Mr. Leberecht, the proportion of noble metal turned out conſtantly from eight hundred and forty to eight hundred and forty-four grains on the quintal or hundred pounds; and that from one fourth to one third of this was Gold, and the reſt Silver. He obſerves that different parcels of ſand, taken up at no great diſtance from one another, differ in degree of richneſs; ſome having yielded above a thouſand grains on the quintal, others only three hundred and fifty, and others again containing nothing but Iron. Theſe eſſays were made, by mixing the ſand (previouſly four times calcined, and as often quenched whilſt red hot, in

Some Gold is alſo met with in ſundry rivers, as the the Tagus, the Ganges, the Rhine, the Saale, the Niger, the Danube, and many others, commonly in fine duſt, often in flat moleculæ, ſometimes ſuſpended by the water in inviſible atoms, which ſettle upon ſtanding, and are diſtinguiſhed by the name of river or waſh Gold. Theſe golden particles, doubtleſs, proceed from ſome mines or veins of Gold, from which the metal has been waſhed out, and carried down by the ſtream. Some have pretended to find perfect Gold in vegetables, particularly in the vine-tree; but on examining thoſe Gold-like ſpecks, or granules, by fire, by Quickſilver, or other trials, they ſoon diſcover themſelves to be no Gold.

Its alloy.

Gold coins and utenſils are not made of pure Gold, but have always an alloy of Silver, or Copper, or both together, by which the Gold is rendered firmer, harder, and more ſonorous (q). When Gold is perfectly pure, it is called *Gold of twenty-four carats*; the meaning

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in water) with twice its weight of granulated Lead, and equal its weight of black flux, ſpreading ſome common ſalt on the ſurface, and melting them, with a fire ſtrongly excited in a blaſt-furnace, till the ſcoriæ flowed thin as water, ſo as not to adhere to the iron-rod with which the matter was from time to time ſtirred.

The precious metal may be extracted alſo, and perhaps more perfectly, by vitrifying the ſand with Glaſs of Lead, and afterwards reviving the Lead. Sulphur, added to the vitreous compounds, readily unites, and changes it into a ſparkling maſs, of a ſemi-metallic aſpect, ſimilar in quality to the natural Lead Ores which participate of Gold and Silver, and yielding its metallic contents by the ſame treatment.

We cannot ſuppoſe, as ſome have done, that this metal proceeded from an antimonial Regulus contained in the menſtruum; any more than, with Mr. Boyle, that it was a part of the Gold actually tranſmuted into Siver. It is by quartation with Silver (ſee page 43.) that Gold is commonly refined; and in that proceſs it always retains a portion of the Silver, ſeparable by Aqua Regia. When Aqua Regia is made with an under proportion of marine Acid, it diſſolves a little Silver along with Gold; and hence probably the Silver obtained on the ſecond diſſolution.

(q) *Alloy.*] Standard Gold contains one twelfth its weight of alloy, moſt commonly of Copper, this metal not weakening the colour as Silver does, but rather heightening it; it is ſuppoſed alſo, perhaps on no very good foundation, that Copper preſerves the malleability of Gold in certain circumſtances wherein pure Gold would become brittle. The ſpecific gravity of this compound is leſs than the mean gravity of the Gold and Copper unmixed.

GOLD. meaning of which is, that in an ounce of the metal all the twenty-four ſcruples are pure Gold. If only twenty-three ſcruples are fine Gold, and the other ſcruple a baſer metal, it is called Gold of *twenty-three carats*; and, in general, the number of carats, by which the fineneſs is expreſſed, denotes the number of ſcruples of fine Gold in an ounce, or twenty-four ſcruples of the mixt. The ancients ſuppoſed the Gold of different countries to differ in their quality; the Armenian to be the beſt, the Hungarian next to it, and the Rheniſh the worſt. But Gold, when perfectly pure, is always one and the ſame, wherever it is to be found; no other differences being obſerved in it than what proceed from an admixture of ſome other metal.

purification from the baſe metals.

There are different methods of ſeparating Gold from admixtures of other metals. If only a baſe metal be mixed with Gold, they may be ſeparated by teſting or cupellation with lead, the baſe metal vitrifying with the Lead, whilſt the Gold remains unhurt (*r*).

Method of parting Gold and Silver.

Silver, which reſiſts the deſtructive power of Lead equally with Gold itſelf, is ſeparated by acid menſtrua. For this purpoſe, we muſt firſt examine whether the mixture contains moſt Gold, or moſt Silver; if the Gold is found to prevail, the metal is to be flatted into plates, or granulated, and put into a proportionable quantity of Aqua regis, which diſſolves the Gold, and leaves the Silver, in the form of powder, at the bottom; the Silver, waſhed and dried, may

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(*r*) *Cupellation with Lead.*] Gold is not ſo perfectly purified by this proceſs as has been commonly ſuppoſed. It almoſt always retains a portion of the lead itſelf, ſmall indeed, but ſufficient to render it brittle; from this it is purified by injecting upon it in fuſion a little Mercury-ſublimate, the acid of the ſublimate corroding the Lead, which now ariſes in ſcoriæ round the ſides of the veſſel, no longer miſcible with the Gold;——nor is Gold to be perfectly purified by cupellation from Copper: it attracts this metal more ſtrongly than it does Lead. If pure Gold be mixed with about one twenty-fourth its weight of Copper, it will ſuffer Lead almoſt totally to work off, but retain nearly all the Copper.——The admixture of Silver varies its affinity to both theſe metals. Mixed with a little Silver it parts with Copper, and not with Lead; mixed with an equal quantity it parts with both.

may be melted into a maſs, with the addition of a little Tallow, and ſome Nitre or Borax, and the Gold may be recovered from the liquor by precipitation. If, on the other hand, the quantity of Silver is much greater than that of the Gold, Aqua fortis is made uſe of, which diſſolves the Silver, and leaves the Gold behind, in form of a black maſs or powder, to be waſhed and melted with Borax. If the proportions of the two metals are nearly equal, the mixture is melted with ſo much freſh Silver, as will make the whole quantity of Silver, at leaſt, three times greater than that of the Gold; if the quantity of Silver is much leſs than this, the beſt Aqua fortis will not be able to extract it from the Gold; if much greater, the ſolution or extraction will go on the faſter; but the Gold will remain in form of powder, ſome particles of which may be in danger of being loſt; if it is juſt thrice the weight of the Gold, the Gold retains the form of the original plates; from the Gold making one fourth of the compound, the proceſs is commonly called *quartation.* This method of parting the two metals is more commodious and effectual than that by Aqua regis, Aqua fortis diſſolving the Siver much ſooner than Aqua regis does the Gold, and the former taking up none of the Gold along with the Silver; whereas the latter almoſt always diſſolves a part of the ſilver along with the Gold, eſpecially if the Aqua regis is made with an under-proportion of marine Acid.

Cementation.

Gold is likewiſe purified from Silver by Acids, applied in form of vapour, free from phlegm. Thus applied, they extract ſmall proportions of ſilver as well as large ones, the Gold being unable to defend that metal againſt the fumes, as it does againſt the Acid, in its liquid ſtate. The marine vapours alſo, in this method of application, corrode the Silver as effectually as the nitrous; the only difference is, that, when corroded by the nitrous, ſuch part as may remain in the pores of the Gold is eaſily diſſolved and waſhed out by water; whereas, with the marine, it

GOLD.

forms a concrete not diſſoluble in water.——The method of performing the proceſs is this: Nitre, or common Salt, (not both at once, for the vapour ariſing from the mixture would diſſolve the Gold as well as the Silver) is mixed with an equal quantity of calcined Vitriol, by which its Acid is extricated in the fire, and twice its weight of powdered Bricks, to prevent the matter from melting and adhering to the ſurface of the metal. The Gold, impregnated with Silver, is flatted into plates; cleanſed by ignition from any external unctuoſity that might impede the action of the acid; then ſtratified, and every where ſurrounded with the mixture, in a crucible or cementing pot; the veſſel cloſely covered and luted; the fire gradually raiſed to a ſlight red heat, and kept up for twelve, ſixteen, or twenty hours.——It is often neceſſary to repeat the cementation, a part of the Silver being apt to eſcape the action of the fumes, eſpecially when the plates are of conſiderable thickneſs: the metal, after one cementation, muſt be melted and laminated afreſh, before it is committed to another. Theſe kinds of operations were formerly often practiſed, but have now, in great meaſure, given place to more advantageous and effectual methods of ſeparation. The mixture with Sea-Salt is commonly called the *regal* cement, Gold being the only metallic body [Platina excepted] that is capable of reſiſting it.

Method of diſtinguiſhing Gold from metals that reſemble it in colour.

The reſiſtance of Gold to Aqua fortis affords a ready method of diſtinguiſhing that metal from compoſitions reſembling it in colour. If a line be drawn with the maſs, upon any ſmooth ſtone that does not diſſolve in acids, a drop of Aqua fortis will take off the mark left by any of the baſe metals, whilſt that made by Gold remains untouched.

If Gold contains Copper, Lead, or other imperfect metallic bodies, along with Silver, it is purified firſt from the baſe metal by the teſt or cupel, and then ſeparated from the Silver by quartation;—it is purified alſo from all the metals by fuſion with Antimony, which abſorbs or ſcorifies all but Gold. Tin is moſt commodiouſly ſeparated by injecting corroſive Sublimate upon the Gold in fuſion. Mercury is diſſipated from it by bare ignition.

Methods of cleanſing it externally, and heightening its colour.

Gold is cleanſed from external impurities, by heating it red-hot, and waſhing it with weak Aqua fortis, brine of Sea-Salt with Tartar, &c. When pale, the colour is heightened by melting it with Copper, and afterwards ſeparating the Copper; or by a mixture of Verdigris and Sal Ammoniac with Vitriol or Nitre (*s*.) Some boil the pale Gold in a ſolution of theſe Salts made in Vinegar; others moiſten the Salts with Vinegar into the conſiſtence of a paſte, which is ſpread upon the Gold, and the metal laid upon burning coals, till the mixture is burnt off. The ſprinkling of the Salts in powder upon the moiſtened Gold, practiſed by ſome, does not anſwer ſo well. It is ſaid that a mixture of Gold with one third, or even with half, its weight of ſilver, acquires, on cementation with Verdigris, the colour of pure Gold; the Silver however is eaſily diſcovered on the touchſtone, by means of Aqua fortis. If a line be drawn with the compound metal, a little Aqua fortis, applied upon the part, will eat out the Silver, and the remaining Gold will appear ſpecked and diſunited (*t*).

II. SIL-

(*s*) *Colour heightened.*] The colour of Gold is improved alſo by fuſion with Nitre, injecting Sal Ammoniac upon it in the fuſion, quenching it in urine, boiling it in a ſolution of Alum. When Borax is uſed as a flux, it is cuſtomary to add a little Nitre or Sal Ammoniac, to preſerve it from being made pale by the Borax.——Juncker reports, from the *Alchymia depudata*, that, by melting Gold with four times its weight of Copper, ſeparating the Copper by Aqua fortis unpurified, then melting the Gold with the ſame quantity of freſh Copper, and repeating this proceſs eight or nine times, the Gold becomes at length of a deep red *puniceous* colour, which ſuſtains the action of Lead, Antimony, and Aqua fortis.

(*t*) *Additional article, PLATINA.*] This metal, ſaid to be found in the Gold-mines of the Spaniſh Weſt-Indies, has but lately become known to Europe. In what form it is met with in the mines, we have no ſatisfactory account; to us it is brought over in ſmall white grains, mixed with a ferrugineous Sand, and ſome other foreign matters. It is called by the Spaniards *Platina*, (a diminutive of *Plata*, Silver) probably from its colour; for, in this reſpect, it greatly reſembles Silver, though in others it comes nearer to Gold.

It

PLATIN.

It poſſeſſes, in effect, almoſt all thoſe properties which have hitherto been ſuppoſed characteriſtic of Gold, and ſtands all the teſts by which that metal has uſually been aſſayed or refined, being nearly as ponderous; equally diſſoluble in Aqua regia, and precipitable by the other metals which diſſolve in that menſtruum; equally reſiſting Aqua fortis, and the other ſimple Acids, and the regal cement; being equally permanent and fixed in the fire; equally indeſtructible by Lead and by Biſmuth; unaffected by Nitre and by Sulphur; incapable of being ſcorified by the ſulphureous part of Antimony, or volatilized by its reguline.

Theſe properties, together with the place where it is found, and the prohibition ſaid to be laid upon its exportation by the king of Spain, afford ſufficient grounds to preſume that the *Smiris Hiſpanica* of the alchemiſts, employed for augmenting Gold, was no other than this Platina, or ſome mineral containing it; more eſpecially as Becher expreſſly declares, that this augmentation was really an abuſe; that the Gold ſo augmented was pale and brittle; and that though it ſtood all the eſtabliſhed teſts of perfect Gold, yet it would not bear amalgamation with Quickſilver, the Mercury retaining the Gold, and throwing out the *Smiris* in form of a reddiſh powder. Platina mixed with Gold is thrown out in the ſame manner; though it is not eaſy, by this method, to obtain a perfect ſeparation.

This metal is, in ſome ſmall degree, malleable; leſs ſo when ignited than when cold. Its ſpecific gravity is to that of Gold, nearly as 18 to 19. The grains cohere in a ſtrong fire, but do not melt, or ſoften, or ſenſibly alter their figure; whether expoſed to its action in cloſe veſſels, or placed in contact with the burning fuel; by themſelves, or with the addition of inflammable, ſaline, vitreous, or earthy fluxes. Compoſitions of Sulphur and fixed alcaline Salts, render it fuſible in the fire, and ſoluble in water.

Platina melts perfectly with all the metals, and occaſions remarkable alterations in their colour, texture, and hardneſs. It deſtroys the malleability of near four times its weight of Tin; with larger proportions it forms compounds tolerably ductile, but renders the texture of the Tin coarſer, and debaſes its colour. All theſe compoſitions tarniſh in the air; thoſe leaſt, which have either a very ſmall or a very large proportion of Platina.

A ſmall quantity is taken up very eaſily by Lead; a large one is taken up much more difficultly than by Tin, and ſubſides in great part upon an abatement of the heat. A little quantity ſtiffens and hardens Lead much more than it does Tin, but a large one does not near ſo much diminiſh its malleability. A leafy or fibrous texture, a purpliſh or blue colour, or a diſpoſition to quickly acquire this colour from the air, are peculiar to the mixtures with Lead.

It unites with Silver more difficultly than with either of the two foregoing, and is more apt to ſubſide from it, on an abatement of the fire; a part of the Silver is likewiſe thrown up during the fuſion, and adheres to the cover of the crucible in little globules: to this, of all the metals, it diſcovers the greateſt repugnance. It diminiſhes the malleability of Silver far leſs than that of Lead or Tin, and does not, in whatever proportion employed, ſo much debaſe its colour, or diſpoſe it to tarniſh.

It diminiſhes the ductility of Gold far leſs than that of any other metal; a mixture even of equal parts of each may, with proper care, be ſomewhat flattened by the hammer. In conſiderable proportions it debaſes the colour more than the uſual alloy, not communicating its own whiteneſs, as the other white metals do, but a peculiar dingy hue, readily diſtinguiſhable by the eye. In ſmall proportions, as one fiftieth, it does not ſenſibly injure either the colour or malleability of Gold.

A large proportion whitens Copper, and renders it very hard and brittle: a ſmall one improves its hardneſs, without ſeeming to injure its colour, or, ſo far as could be judged, its malleability. Theſe mixtures bear a fine poliſh, and do not tarniſh in the air ſo much, or ſo ſoon, as pure Copper.

It renders caſt Iron exceſſively hard, in ſome degree tough, ſuſceptible of a fine poliſh, and not apt to tarniſh. The compound, cemented with the Steel-making mixtures, is not changed into Steel, but ſomewhat ſoftened, and more ſo than by the ſubſtances which ſoften pure caſt Iron.

It unites with Biſmuth, Zinc, and Regulus of Antimony, as perfectly as with the malleable metals. It increaſes the hardneſs of the two latter, but not of the former; diſpoſes Biſmuth to change its colour in the air, but not the other two.

Its effects on the compound metals are ſimilar to thoſe which it produces on the ſimple ones. Braſs it renders white, hard, brittle, ſuſceptible of a fine poliſh, and not liable to tarniſh; as it does the Copper, and, in ſome degree, the Zinc, of which that metal is compoſed. Mixtures of it with Copper and Tin are more apt to tarniſh than thoſe with Copper only, and leſs than thoſe with Tin only.

All the compoſitions of Platina with metals are more brittle when ignited than when cold. Their ſpecific gravity is leſs than the medium of the gravities of the two ingredients. All the metals may be made to take up equal their own weight of the Platina; ſome metallic compoſitions of Tin, Copper, *&c.* twice their weight. Several of the mixtures melt, and appear uniform to the eye, by a moderate heat, but the union is never perfect without a ſtrong one.

After Platina has thus been brought into fuſion by metallic additions, it proves, on ſeparating the metal, as refractory as at firſt. In cupellation with Lead, as ſoon as the Lead has been worked off to a certain point, the matter becomes conſiſtent, and can no longer be made to melt, or to part with any more of the Lead. The caſe is the ſame in ſcorifying Biſmuth from it, or diſſipating regulus of Antimony or Zinc; the Platina at length refuſing to melt, and defending a part of thoſe deſtructible metals from the action of the fire and air. Platina cupelled with Lead, unleſs the bottom turns out ſpongy, is found to be remarkably more ponderous than at firſt, notwithſtanding its retaining a conſiderable portion of that lighter metal: the ſpecific gravity of ſome of the neater and more ſolid beads was very nearly the ſame with that of fine Gold.

Platina diſſolves in Aqua regis very ſlowly and difficultly into a dark browniſh red liquor; a few drops of which tinge a large quantity of water of a fine golden colour. The ſolution, duly evaporated, ſhoots into deep yellowiſh red Cryſtals. It gives no ſtain to hot Marble, or to the ſkin, bones, or other ſolid parts of animals. Oil of Vitriol, added to the concentrated ſolution, precipitates the Platina, but makes no change if the liquor is previouſly diluted. The Platina is precipitated by alcalies, and by Sal Ammoniac, in form of a red powder; this, expoſed to the fire, becomes blackiſh, without fulminating; waſhed with water, it acquires a ſimilar colour, tinging a large quantity of the fluid of a golden hue. None of the ſubſtances, that have been tried, occaſion, ſingly, a complete precipitation, a part of the Platina always remaining diſſolved. By alternate additions of alcalies and Sal Ammoniac, or by adding Tin after either of theſe, the whole is thrown down, and the liquor left colourleſs. Volatile alcalies added, after the preci-

PLATIN.

pitation is completed, rediſſolve a part of the Platina, and more than they do of Gold by the ſame treatment. The precipitates, thoroughly edulcorated by boiling water, diſſolve in ſpirit of Salt, much more difficultly and ſparingly than thoſe of Gold. The precipitates, made both with metallic and ſaline ſubſtances, reſiſt vitrification.

Solution of Platina does not ſtrike a purple colour with Tin, nor prevent Gold, mixed with it, from ſtriking this colour. The Platina is not revived from its ſolution by inflammable ſpirit, nor taken up by eſſential Oils or Æther, and does not prevent Gold from being revived by the former, or taken up by the two latter. It is not precipitated by ſolution of green Vitriol, nor prevents Gold from being precipitated by that Salt.——Theſe experiments afford ready means of diſtinguiſhing ſmall proportions of Platina mixed with Gold, or of Gold mixed with Platina, and of perfectly purifying or ſeparating the two metals from one another.

A more particular account of the principal experiments I have hitherto made on this extraordinary metal, may be ſeen in the *Philoſophical Tranſactions* for the years 1754, and 1757, from whence the foregoing general reſults are extracted. Mr. Scheffer has likewiſe given ſome curious experiments on this metal, which he calls white Gold, in the *Kongl. Suenſka vetenſkaps academiens handlingar*. The very ſmall quantity of Platina, which he was furniſhed with, did not permit his carrying theſe experiments to any conſiderable length; ſo far as they go they agree ſufficiently with mine, except in regard to the effect of the Arſenic. He reports that Platina, ſtrongly heated, melts in an inſtant upon the contact of a very ſmall proportion of white Arſenic. I have treated Platina and Arſenic in different ways, with and without inflammable additions, by the moſt intenſe fires I was able to excite, without ever obſerving it become fluid. There was commonly a tendency to fuſion on the ſurface, which appeared in part ſmooth, bright, and united; but the internal part of the maſs was conſtantly found to conſiſt of unchanged grains of Platina. It was the ſmallneſs of the quantity which prevented Mr. Scheffer from obſerving that the fuſion was only apparent and ſuperficial.

II. SILVER.

SILVER.

Its general properties, ductility,

SILVER (the *Luna*, *Diana*, *Proſerpina*, *Regina metallorum*, of the Chemiſts,) is the moſt perfect, ductile, and fixed, in the fire, of all metals after Gold (*u.*) A ſingle grain has been drawn into a wire three yards in length, and the wire flatted into a plate an inch broad. In common fires it ſuffers no diminution of its weight, and, kept in the vehement heat of a glaſs-houſe furnace for a month, it loſes no more than one ſixty-fourth. In the focus of Tſchirnhaus's large burning-glaſs it ſmokes for a long while, then contracts a greyiſh aſh on the ſurface, and at length is totally diſſipated.

fixity;

expoſed to a burning-glaſs.

Solution in the nitrous Acid.

The proper menſtruum of Silver is the nitrous acid, which, if well dephlegmated, will diſſolve equal its own weight; the ſolution ſtains the ſkin black (*x*). Some

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(*u*) *Silver.*] Silver is a ſoft, flexible metal, of little or no elaſticity: by hammering it becomes moderately hard, elaſtic, and ſonorous; more ſo than Gold, leſs than Copper or Iron. Its ſpecific gravity is to that of water nearly as 10¾ to 1. It melts, in a bright and red heat, a little ſooner than Gold; and, when in fuſion, appears a perfect ſpeculum. Like Gold, it continues ductile when heated, as well as when cold; loſes a little of its ductility by ſudden cooling; proves brittle when heated by hammering; and regains its priſtine malleability on being nealed, that is, ſlightly ignited, and ſuffered to cool very leiſurely. It ſeems to be perfectly fixed in the greateſt degree of culinary fire, the ſmall diminution, which, in ſome experiments of this kind, has happened at firſt, being apparently not of the Silver itſelf, but of ſome other metal with which it had been debaſed.

(*x*) *Solution ſtains,* &c.] It ſtains hair, bones, and other ſolid parts of animals, and different kinds of wood, of all the intermediate ſhades, from a light brown to a deep and laſting black. The liquors commonly ſold for ſtaining hair brown or black are no other than ſolutions of Silver in Aqua fortis, ſo far diluted in water as not ſenſibly to corrode the hair.

It gives a permanent ſtain likewiſe to ſundry ſtones; not only to thoſe of the ſofter kind, as marble, but to ſome of conſiderable hardneſs, as Agates and Jaſpers. The ſolution, for this purpoſe, ſhould be fully ſaturated with the metal, and the ſtone, after the liquor has been applied, expoſed for ſome time to the ſun. Mr. du Fay obſerves, (in a paper upon this ſubject in the French Memoirs for the year 1728) that if the ſolution be repeatedly applied, it will penetrate, in the whitiſh Agate or Chalcedony, about one twelfth of an inch; that the tincture does not prove uniform, on account of the veins in the ſtone; that the colours, thus communicated by art, are readily diſtinguiſhable from the natural, by their diſappearing, upon their laying the ſtone for a night

SILVER. Some have thought to increaſe the ſtrength of the acid, by drawing it over from a quantity of freſh Nitre, and been ſurprized to find that, inſtead of acting more powerfully upon Silver, it would not now diſſolve that metal at all, only corroding it into a white powder; and that, on the other hand, it now proved a menſtruum for Gold, which before it had no effect upon. Theſe alterations depend wholly upon the Nitre containing Sea Salt; whoſe Acid is expelled in the diſtillation by a part of the nitrous, and forced over along with the reſt; pure Spirit of Nitre, drawn over from pure freſh Nitre, diſſolves Silver, and leaves Gold untouched, as at firſt.

Cryſtals. Solution of Silver, evaporated a little, ſhoots in the cold into Cryſtals (*y*), intenſely bitter and corroſive, and hence called by ſome *fel metallorum*, the gall of

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night in Aqua fortis; that, on expoſing it to the ſun afterwards for ſome days, the colour return; that the ſolution gave ſomewhat different tinctures to different ſtones: to oriental Agate a deeper black than to the common Chalcedony; to an Agate ſpotted with yellow, a purple; to the Jade-ſtone, a pale browniſh; the common Emerald, an opake black; to common Granate, a violet unequally deep; to Serpentine-ſtone, an olive; to Marble, a reddiſh, which changed to a purple, and fixed in a brown; that on Slates, Talcs, and Amianthus, it had no effect.

(*y*) *Cryſtals.*] The Cryſtals of Silver ſhoot into thin, colourleſs, tranſparent plates, approaching to a triangular figure. They readily diſſolve in water, and, by the aſſiſtance of warmth, in Spirit of Wine. Expoſed for ſome time to a moderately ſtrong fire, they part by degrees with all the Acid, and return into Silver again; though ſcarcely without ſome little loſs, unleſs borax or alcaline fluxes are added, to collect and reunite the particles of the metal.—If laid on a burning coal, the nitrous acid, deflagrating with the inflammable matter, as this acid in all its combinations does, is quickly conſumed, and the Silver revived. I have not obſerved in this experiment any conſiderable volatilization of the Silver; though in the *Acta naturæ curioſorum, tom.* vi. there is a remarkable hiſtory of Silver diſſolved in the nitrous acid being volatilized in cloſe veſſels, by means of Charcoal. Four ounces of pure Silver being diſſolved in Aqua fortis, and the ſolution ſet to diſtil in an earthen retort, a white tranſparent butter aroſe into the neck, and nothing remained behind; by degrees the butter liquefied, and paſſed down into the phlegm in the receiver; the whole being now poured back into the retort, the Silver aroſe again along with the acid; on adding Sea-Salt to this volatilized ſolution, the Silver was precipitated into a Luna Cornea. The volatilization being attributed to the liquor having ſtood in an elaboratory where Charcoal was bringing in, the experiment was repeated with a freſh ſolution of Silver, mixed with a little powdered Charcoal, with the ſame event.

Lunar Cauſtic.

of metals: the cryſtallization is promoted by dropping in a little Spirit of Wine before the liquor is ſet to ſhoot. The cryſtals, or the ſolution inſpiſſated to dryneſs, melt in a ſmall heat, and form, on cooling, a dark coloured maſs ſtill more corroſive, their phlegm having been diſſipated in the fire. This maſs is the lunar Cauſtic or infernal Stone of the ſhops; for the greater conveniency of uſing it as a Cauſtic, it is commonly caſt in proper moulds into ſlender cylindrical pieces. The Cryſtals have been given internally, as purgatives and diuretics, and hence named *Catharticum lunare*, and *hydragogum Angeli Salæ*; they are a medicine of great activity, too great to be taken with ſafety.

Arbor Dianæ.

Precipitation of Silver.

If ſolution of Silver be diluted with pure water, a conſiderable quantity of pure Mercury added, and the whole ſet by in a cold place, there will form by degrees a precipitation and cryſtallization reſembling a little tree, with its root, trunk, and branches, called *Arbor Dianæ*, or the philoſophic Silver-tree. Lemery gives another method of making an Arbor Dianæ, by adding to ſolution of Silver ſome warm diſtilled Vinegar (z).——Silver is precipitated from its ſolution by (*a*) Copper, Iron, Tin, and Zinc.

(z) *Vegetations.*] Another kind of artificial vegetation, as it is called, may be produced, by ſpreading a few drops of ſolution of Silver upon a glaſs-plate, and placing in the middle a ſmall bit of any of the metals that precipitate Silver, as particularly of Iron. The Silver quickly concretes into curious ramifications all over the ſurface of the plate. Other metallic ſolutions afford alſo vegetations on the ſame treatment, but none ſo elegant ones as that of Silver.

(*a*) *Precipitation of Silver.*] Silver is precipitated from Aqua fortis by all the metals which diſſolve in that acid; readily and copiouſly at firſt, but ſlowly and difficultly towards the end. The menſtruum generally retains ſome portion of the Silver, as the Silver almoſt always does of the metal which precipitated it:——The refiners, for recovering the Silver from Aqua fortis after parting, employ Copper. The ſolution, diluted with water, is put into a copper-veſſel, or into a glaſs one with thin plates of Copper, and ſet in a gentle warmth: the Silver begins immediately to ſeparate from the liquor, in form of fine grey ſcales or powder; a part of the Copper being diſſolved in its place, ſo as to tinge the fluid more and more of a bluiſh-green colour; the plates are now and then ſhaken, that ſuch part of the Silver as is depoſited upon them may fall off, and ſettle to the bottom. The digeſtion is continued till a freſh bright plate, kept for ſome time in the warm liquor, is no longer

Copper is commonly made choice of, the Precipitate obtained by that metal being the pureſt, though it is never entirely free from ſome portion of the Copper. This calx is employed for cold ſilvering, mixed with Nitre, Sal Ammoniac, and common Salt, in the proportion of one part of each of the Salts to two of the lunar Calx; ſome, inſtead of the Precipitate, take Silver leaf, with equal of its weight of Creme of Tartar, and the ſame quantity of common Salt.

Combination of Silver with the marine acid.

The marine acid does not diſſolve Silver (*b*), but precipitates it from the nitrous. Upon adding, to a ſolution

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longer obſerved to contract any powdery matter on the ſurface; when the liquor is poured off, and the Precipitate waſhed with freſh parcels of boiling water. The ſmall portion of Silver, which the Acid commonly ſtill retains, may be precipitated by common Salt; the Copper, which the Silver retains, may be in part ſcorified and ſeparated by fuſion with Nitre. It is obſervable, that though the Acid in this proceſs ſaturates itſelf with the Copper, in proportion as it lets go the Silver, yet the quantity of Copper, which it takes up, is not near ſo great as that of the Silver which it depoſites. One drachm of Copper will precipitate three of Silver, and ſaturate all the acid that held the three drachms diſſolved.

Abſorbent earths, as Chalk or Quick-lime, throw down a part of the Silver, but leave a very conſiderable part ſuſpended in the liquor. If the earth be moiſtened with the ſolution into the conſiſtence of a paſte, and expoſed to the ſun, it changes its white colour to a dark purpliſh black: diſtinct characters may be exhibited on the matter, by intercepting a part of the ſun's light, by threads, ſlit paper, *&c.* placed on the outſide of the glaſs. Culinary fire does not affect its colour: after the maſs has been exſiccated by this, it changes as before, upon expoſure to the ſun.

Volatile alcaline Spirits, added to a ſolution of Silver precipitate little. Pure fixt Alcalies, and Alcalies rendered cauſtic by Quick-lime, throw down the whole. Fixt Alcalies, impregnated with inflammable matter, by calcination with animal coals, occaſion at firſt a conſiderable precipitation; but, if added to a larger quantity, take up great part of the metal again. Mr. Margraff relates, that edulcorated calces of Silver totally diſſolve, both in a Lixivium of theſe Alcalies, and in volatile Spirits; and that the marine acid precipitates the Silver from the volatile, but not from the fixt alcaline ſolution.——Kunckel reports, that the calx, precipitated by volatile ſpirits made with Quick-lime, fulminates or explodes in the fire; and that, by inſpiſſating a ſolution of pure Silver, melting the dry reſiduum, pouring it on Spirit of Urine ſuperſaturated with Salt, and ſetting the mixture in a gentle warmth, a blood-red maſs is produced, ſo tough as to be wound about the fingers.

(*b*) *Marine acid.*] Strong Spirit of Salt corrodes leaf Silver into a white powder; on filings, or larger maſſes, it has no effect. The highly concentrated acid, applied, in the form of vapour, to maſſes of Silver at the ſame Time ſtrongly heated, readily corrodes them. Thus ſolution of the metal made in Aqua fortis, either the pure acid of Sea-Salt, or the Salt in ſubſtance, or Sal Ammoniac, the liquor inſtantly becomes milky, and, on ſtanding, depoſites the Silver now combined with the marine acid into a white powder. This, when ſufficiently waſhed with water, proves inſipid, though containing ſo much acid as to weigh one fourth more than the Silver employed. It does not diſſolve in water, Spirit of Wine, Aqua fortis, or Aqua regis, but is, in ſome ſmall degree, acted on by the vitriolic acid. It melts in the fire as ſoon as it begins to grow red-hot; and, on cooling, forms a ponderous browniſh maſs, which, if caſt into thin plates, proves ſemi-tranſparent and ſomewhat flexible, like horn; whence its name *Luna Cornea.* A ſtronger fire does not expel the acid from the Siver, the whole concrete either ariſing in fumes, or ſinking through the veſſel, without any ſeparation of its parts: it may be ſublimed like Arſenic, with which it has, in many reſpects, a great analogy. If mixed with fixt Alcaline Salts, or inflammable ſubſtances, as Oil or Tallow, and melted in a crucible, the acid is abſorbed and expelled, and the Silver recovered pure (*c.*)

Luna Cornea.

Silver volatilized.

The

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if filings, grains, or plates, of the metal be mixed with about twice their weight of Mercury ſublimate, and expoſed to a moderate fire in a retort or other proper veſſel, the marine acid of the ſublimate will be abſorbed by the Silver, and form with it a Luna Cornea; whilſt the Mercury, now diſengaged from the acid, diſtils in its running form. ——The marine acid is commonly ſuppoſed incapable of diſſolving Silver into a liquid ſtate. Henckel reports, in his tract *de appropriatione*, that if red Silver ore, which conſiſts of Silver intimately blended with red Arſenic, be digeſted in Spirit of Salt, the Silver will be extracted, and kept permanently diſſolved.

(*c*) *Luna Cornea—Silver recovered pure.*] Luna Cornea is moſt commodiouſly prepared, by diluting a ſolution of Silver with ten or twelve times its quantity of water, and adding by degrees a ſolution of Sea-Salt, ſo long as it occaſions any turbidneſs or milky hue. The whole is then to be ſet by till the white powder has ſettled: when the clear liquor is to be poured off, and the precipitate waſhed with freſh parcels of boiling water. If the Silver contained any portion of Copper, which it always does after the common methods of purification, that metal will here be ſeparated, and left diſſolved in the liquor; pure Sea-Salt precipitating no metallic body but Silver, Lead, and Mercury. Hence

SILVER.

Combination with the vitriolic acid.

The vitriolic acid alſo precipitates Silver from the nitrous, but does not act upon Silver in its metallic ſtate, unleſs high concentrated and aſſiſted by a boiling heat (*d*). The marine acid precipitates Silver from the vitriolic, in the ſame manner as from the nitrous.

Amalgamation.

Mercury very readily amalgamates with Silver leaf. It eaſily unites likewiſe with the calx of Silver precipitated by Copper, but does not touch the calces precipitated by Salts.

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Silver is brought by this proceſs to a degree of purity ſcarce procurable by any other known means.

The Silver may be recovered from the Luna Cornea, by fuſion with alcaline and inflammable fluxes as directed by the author, or with certain metallic bodies; but in theſe operations there happens always a conſiderable loſs of the Silver, a part of the volatile calx being diſſipated by the fire, before the alcali or metal can abſorb its acid. Mr. Marggraf has diſcovered a method of reviving the Silver with little or no loſs; Mercury, aſſiſted by volatile Salts, imbibing it by trituration, without heat. One part of Luna Cornea, and two of volatile Salt, are to be ground together in a glaſs mortar, with ſo much water as will reduce them into the conſiſtence of a thin paſte, for a quarter of an hour or more: five parts of pure Quick-ſilver are then to be added, with a little more water, and the triture continued for ſome hours. A fine amalgam will be thus obtained; which is to be waſhed with freſh parcels of water, ſo long as any white powder ſeparates. Nearly the whole of the Silver is contained in the amalgam, and may be recovered perfectly pure by diſtilling off the Mercury. The white powder holds a ſmall proportion, ſeparable by gentle ſublimation: the matter which ſublimes is nearly ſimilar to Mercurius dulcis.

Luna Cornea totally diſſolves in volatile alcaline Spirits, without any ſeparation of the metal;——expoſed to the fire in a cloſe copper veſſel, it penetrates the Copper, and tinges it throughout of a Silver colour. ——Kunckel obſerves, that when carefully prepared, melted in a glaſs veſſel, and ſuffered to cool ſlowly, (to prevent its cracking) it proves clear and tranſparent, may be turned into a lathe, and formed into elegant figures. He ſuppoſes this to be the preparation which gave riſe to the notion of malleable Glaſs.

(*d*) *Silver with vitriolic acid.*] Oil of Vitriol, aſſiſted by a boiling heat, corrodes into a ſaline maſs half its weight of ſilver filings. This compound diſcovers a remarkable attraction to Mercury; it coagulates and hardens as much Quick ſilver as the acid weighed at firſt: if the hard concrete be diluted with freſh acid, it melts eaſily in the fire, and does not part with the Mercury in the greateſt heat that glaſs veſſels can ſupport. The vitriolic acid by itſelf ſtrongly retains Mercury, but not near ſo much as when thus combined with Silver.

Silver, thus corroded by the vitriolic acid, or precipitated by it from the nitrous, may be in great part diſſolved into a liquid ſtate, by cautiouſly applying a very little water at a time; and more effectually, by repeating the coction in freſh Oil of Vitriol. The calx, precipitated from this ſolution by the marine acid, is ſaid, by Kunckel, to be more volatile and penetrating than the common Luna Cornea.

Silver with Sulphur.

The vapours of ſulphureous ſolutions ſtain Silver yellow or black. Sulphur melted with Silver debaſes its colour to a leaden hue, renders it more eaſily fuſible than, and makes it flow ſo thin as to be apt, in a little time, to penetrate the crucible: in a heat juſt below fuſion, a part of the Silver ſhoots up, all over the ſurface, into capillary efflореſcences. Aqua fortis, the ſolvent of pure Silver, does not act upon the Silver in this compound, but fixt alcaline Salts, the menſtruum of Sulphur, may be made to abſorb that ingredient; the Alcali however, when combined with the Sulphur, will take the Silver up again. If the ſulphurated Silver be mixed with Mercury ſublimate, and expoſed to the fire, the Mercury of the ſublimate will unite with the Sulphur, and carry it up in the form of Cinnabar, whilſt the marine Acid of the ſublimate unites with the Silver into a Luna Cornea, which remains at the bottom of the glaſs. Fire alone, continued for ſome time, is ſufficient to expel the Sulphur from Silver.

Purification of Silver.

Tinctura Lunæ.

Silver is purified from the baſer metals by cupellation with Lead. It always retains, however, after that operation, ſome ſmall portion of Copper, ſufficient to impregnate volatile Spirits with a blue tincture, which ſome have erroneouſly ſuppoſed to proceed from the Silver itſelf. It is purified from this admixture by melting it twice or thrice with Nitre and Borax. The Scoriæ, on the firſt fuſion, are commonly blue; on the ſecond, green; and on the third, white, a mark of the purification being compleated. But the moſt effectual purification is the revival of Silver from Luna Cornea.

Silver boiled white.

Silver is purified and whitened externally by boiling in a ſolution of Tartar and common Salt. This is no other than an extraction of the cupreous particles from the ſurface of the Silver, by the acid of the Tartar acuated with the common Salt.

The Silver employed for coins and utenſils, has always an admixture of Copper, which improves its hardneſs and ſonorouſneſs. Its degree of fineneſs is

Alloy.

expreſſed among us by *loths* or half ounces: a *marck* contains ſixteen half ounces. The Silver is ſaid to be of ſixteen *loths*, when all the ſixteen half ounces are pure Silver; of fifteen, when only fifteen half ounces are pure Silver, and the other Copper, *&c.*—Moſt of the other metallic bodies render it brittle. One part of Tin deſtroys the malleability of above an hundred parts of Silver; and Regulus of Antimony has this effect in a ſtill greater degree. Both Regulus of Antimony and Arſenic render a part of the Silver volatile in the fire (*e.*)

Where found.

Silver is found in all countries, but moſt plentifully in America, particularly in Peru and Potoſi, from whence large quantities are brought annually into

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(*e*) *Silver with other metals.*] Its colour is debaſed by all the metals, and its malleability greatly injured by all but Gold and Copper. The Engliſh ſtandard Silver contains one part of Copper to twelve and one third of pure Silver.——Silver diſcovers, in ſome circumſtances, a great attraction to Lead; though it does not retain any of that metal in cupellation, as Gold does. If a mixture of Silver and Copper be melted with Lead, in certain proportions, and the compound afterwards expoſed to a moderate fire, the Lead and Silver will melt out together, bringing very little of the Copper with them: by this method Silver is often ſeparated from Copper in the large works. The effect does not wholly depend upon the different fuſibility of the metals; for if Tin, which is ſtill more fuſible than Lead, be treated in the ſame manner with a mixture of Copper and Silver, there will be no eliquation, the three ingredients, here, ſtrongly attracting one another, ſo as to come all into fuſion together. Again, if Silver be melted with Iron, and Lead added to the mixture, the Silver will forſake the Iron to unite with the Lead, and the Iron will float by itſelf on the ſurface.

Silver with vitreous matters.] Precipitates or calces of Silver melted with vitreous ſubſtances, impart to them a yellow colour. Kunckel obſerves, that, when the glaſs is ſtrongly ſtirred in fuſion with an Iron rod, or blown into veſſels, it changes its uniform tinge into an opake milkineſs, variegated with yellow and other colours: the preparation of Silver he employs is Luna Cornea. This, or the other precipitates, ſpread upon a glaſs plate, adhere and ſtain it yellow by ignition without fuſion: hence their uſe in painting on Glaſs.

The moſt beautiful yellow enamel for Porcelane hitherto diſcovered, (communicated in the Phil. Tranſ. and the Swediſh Acts) owes its colour to Silver. A Glaſs made from three parts of Litharge and one of Flint, is reduced into groſs powder, and a ſolution of about one twentieth its weight of Silver poured upon it; the mixture is ſtirred together, exſiccated and melted again, and, when in thin fuſion, poured out. This compoſition, ground into fine powder, is applied on the Porcelane previouſly heated, and the ignition continued, under a muffle, till the powder melts, which is known by its gliſtening. The ware is then taken out of the furnace, and, whilſt it continues red-hot, held over the ſmoke of burning vegetables, which calls forth the beautiful colour.

SILVER. into Europe. It is met with either in its perfect metallic ſtate, or in the form of ore, or blended in the ores of other metals.

Native Silver. Native malleable Silver occurs not unfrequently, in different Stones, Earths, and in moſt kinds of Sands; in ſmall pieces, of different figures, chiefly filaments or ſcales. It generally contains ſomewhat arſenical, but never holds any Gold, though native Gold is ſeldom free from Silver.

Ores of Silver. The principal ores of Silver are, (1.) *Ganſekothig ertz*, gooſe-dung ore, ſo called from its colour; this is ſurrounded, and penetrated with efflореſcences of capillary Silver. (2.) *Glaſertz*; compoſed of Silver and Sulphur. This ore is of an irregular figure, ſometimes cubical, ſometimes of eight or more ſides. When pure, it may be hammered or cut almoſt like Lead; but if penetrated by foreign matters it falls in pieces from a blow: the pieces ſingly prove malleable. There are ſome ſorts brittle throughout, probably from an admixture of Arſenic. Its colour is blackiſh, ſometimes brighter and ſometimes darker. There is one ſort of a grey colour almoſt like the fallow ore, but differing from that ore in containing no Copper. It melts in the fire as ſoon as it begins to grow red-hot. Its yield of Silver is variable, but always large, amounting commonly to about three fourths of its weight. (3.) *Hornertz*, horn ore; externally irregular, internally compoſed of fine leaves laid together and ſemi-tranſparent like horn. It yields, like the foregoing, both to the hammer and the knife. Its colour is whitiſh, yellowiſh, or browniſh. It is commonly foul on the outſide, but may be eaſily diſtinguiſhed by cutting or bending it. In the fire it emits both an arſenical and ſulphureous fume; and commonly affords two thirds its weight of Silver. (4.) *Rothgulden ertz*, red Silver ore, is ſometimes of a deep tranſparent red, and ſometimes darker. It is diſtinguiſhed from Cinnabar, by its colour inclining not to an aurora or brick red, but to the garnet or ruby red, or a purple red; though there are red

SILVER. Silver ores alſo of a dull brick hue. The colour of Cinnabar is improved, but that of Silver ores debaſed, by grinding them into fine powder. This ore is very ponderous, melts in the fire before it becomes red hot, and emits thick fumes ſmelling ſtrongly of Arſenic. It conſiſts of Silver and Arſenic, with a little ſulphur; and with theſe ingredients, or with equal parts of Arſenic and native Silver, it may be imitated by art. The quantity of Silver in the deep red ſorts is commonly from ſixty to ſixty-two pounds on the hundred. The yield of the darker kinds is inconſtant. Theſe laſt hold commonly a little Iron. (5.) *Weiſſguldenertz*, white Silver ore, is of a bright grey colour, ponderous and brittle. When pure it contains ſeven pounds of Silver on the hundred, but a larger quantity of Copper. It conſiſts of Silver, Copper, Antimony, Arſenic, and Sulphur. Several ſorts contain likewiſe Iron, and hold but very little Silver, as two ounces on the hundred weight: theſe are of a paler and brighter colour than the others, and called plain *Weiſſertz*, white ore. The white Silver ores have a great reſemblance in colour to the paler cobalts; theſe laſt however are ſenſibly whiter, and incline a little, like Biſmuth, to a reddiſh or yellowiſh caſt. (6.) The *fahlertz* and *fahlkupferertz*, fallow ore and fallow Copper ore, are ranked among the ores of Silver, though they belong more properly to thoſe of Copper. Their colour is a dark grey. They are found among, and ſometimes blended with, Copper ores and Copper pyritæ. They hold from four ounces to ſome pounds of Silver upon the hundred. (7.) *Federertz*, feather ore, is compoſed of extremely fine fibres or hairs. It holds two ounces of Silver on the hundred weight, and contains both Arſenic and Sulphur, for it yields, on ſublimation, a yellow Arſenic. (8.) *Ruſs*, ſooty ore, conſiſts of a fine, ſoft, black duſt, which is commonly lodged in clefts. It is very rich in Silver, yielding ſometimes half its weight.

Silver is extracted from its matrices by amalgamation with Mercury; and from its true ores by fuſion, or by ſcorification with Lead in the ſame manner as Gold (*f*).

SILVER.

CLASS II. IMPERFECT METALS.

Malleable metals; — reſiſting the fire in cloſe veſſels; — in open ones, calcining; — when calcined, or corroded by Acids, not revivable again into their metallic form without the addition of inflammable matter.

IMPERF. METAL. BODIES.

Contain an inflammable matter.

THESE metals appear actually to contain an inflammable principle, which is burnt out in the calcination, and extracted from them by acids. Nitre, which deflagrates with and diſſipates the inflammable principle where-ever it is to be found, deflagrates with the imperfect metals, and thus occaſions inſtantly the ſame change that fire alone would more

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(*f*) *Extraction of Silver from the ore.*] In the mines of the Spaniſh Weſt-Indies, the Silver is for the moſt part native, or only embedded in earths and ſtones, ſo as to be ſeparable by comminution, ablution, and amalgamation, nearly in the ſame manner as Gold. The method of conducting the proceſs is particularly deſcribed by Alonſo Barba.

The proper ores of Silver are moſt common in Germany. The black malleable ore, the ſecond of thoſe above enumerated, is the only one that has been met with in England, and this but rarely. The Silver is extracted by calcination and fuſion. The Sulphur and Arſenic, (one, or other, or both of which, are blended in all the true ores of Silver) are totally diſſipable by ſimple calcination; Silver having little affinity with thoſe minerals, and parting with them more readily than any of the baſer metals does. The Silver may afterwards be ſeparated from the remaining earthy or ſtony matters, by fuſion or ſcorification with Lead, which anſwers the ſame purpoſes here as in the extraction of Gold from its ores or matrices, ſee page 40. Silver may likewiſe be got out from the ore, by fuſion with a large portion of Lead without calcination, and in ſome caſes to better advantage than when that proceſs is premiſed: for Lead abſorbs from this metal both Arſenic and Sulphur; and Arſenic remarkably promotes the vitrification of Lead, and forms with it a glaſs far more active as a flux for refractory matters than the ſimple glaſs of Lead.

Moſt of the Engliſh Lead ores contain ſome portion of Silver; and ſome of them ſo much as to be worked for this metal to advantage. Thoſe of Cardiganſhire are ſaid to yield from ten to twenty pounds on the ton. Theſe are firſt run down as other Lead ores; and the Silver afterwards extracted from the Lead, by working off the Lead upon a teſt.

IMPERF. METAL. BODIES.

more ſlowly produce: ſome of theſe metals emit viſible flames by themſelves.

Their inflammable part the ſame with that of vegetables and animals.

The phlogiſtic principle is the ſame in one metal as in another, in metals as in other bodies, in the mineral as in the vegetable and animal kingdoms. When metals, by the loſs of their own phlogiſton, have been changed into a calx or vitreous maſs, the introduction of any other inflammable matter, from vegetables or animals, Charcoal, Reſins, Oils, Fats, &c. inſtantly reſtores their metallic appearance, and all their priſtine qualities.

Their other principles.

The calx differs greatly in different metals: it is on this, that the diſtinguiſhing characters of each particular metal depend, the calx of one metal forming always with phlogiſton no other than the ſame metal again. Theſe calces are ſuppoſed to conſiſt of a certain fixed vitreſcible earth, and a more volatile principle called mercurial. When metals have been but barely calcined, they have loſt only their phlogiſton, and are recoverable by the introduction of freſh phlogiſton. A more thorough calcination, by long continuance of fire or by additions, diſſipates a part of this mercurial principle; and as no method has been diſcovered of ſupplying it by art, the quantity of metal revivable will be proportionably leſs. The proceſs is capable of being carried ſo far, that no metal at all ſhall be recovered, and that the calx ſhall differ but little from a mere earth.

The perfect metals, of the foregoing claſs, though not reſoluble by theſe operations into any diſſimilar parts, are ſuppoſed, from analogy, to conſiſt of the like principles.

I. LEAD.

LEAD.

LEAD, *Saturn*, is a pale or livid white metal; ſoon loſing its brightneſs in the air, and contracting a blackiſh or greyiſh aſh colour; very ſoft and

Gravity.

and flexible (*g*); unelaſtic and unſonorous; the heavieſt of all metallic bodies but Gold, Quickſilver [and Platina]: it is upwards of eleven times heavier than an equal bulk of water.

Fuſibility.

It melts in a very ſmall degree of fire, long before it grows red-hot: in a ſtrong red heat, it boils and emits viſible fumes (*h*). It loſes of its malleability in proportion as it is heated: by nimble agitation, when it is juſt ready to melt, or when returning from a fluid to a conſiſtent ſtate, it may ce divided into ſmall grains or powder. Granulated Lead is commonly prepared, by pouring the melted metal into a wooden box rubbed on the inſide with Chalk, and ſtrongly ſhaking it till it ſets or becomes ſolid. When large quantities are prepared, a wooden trough is made

Granulation.

(*g*) *Lead—flexible,* &c.] Lead is the ſofteſt and moſt flexible of all metallic bodies; eaſily cut with a knife, ſhaved with a plane, grooved for windows by being drawn through the glazier's vice, flatted, by paſſing betwixt wooden rollers, into large thin ſheets. When broke by repeated bendings, backwards and forwards, each piece appears drawn out ſmooth to an edge, like the fracture of well nealed Gold or Silver. It is not however ductile to any great degree, either in the form of wire or leaf; in this reſpect coming far ſhort of all the other malleable metals.

Some have preferred, for mechanic uſes, the milled Lead, or flatted ſheets, to the caſt; as being more equal, ſmooth, and ſolid. But whatever advantages of this kind, the milled ſort may appear to have at firſt, they are not found to be very durable. When the Lead is ſtretched between the rollers, its cavities muſt neceſſarily be enlarged: the particles of metal, that may be ſqueezed into them, can have no union or adheſion with the contiguous particles; and of conſequence muſt be liable, from bending, blows, jarrs, or other light external cauſes, to ſtart out again, and leave the maſs ſpongy and porous.

Lead yields the dulleſt and weakeſt ſound of all metallic bodies. Reaumur obſerves, that it is rendered ſonorous, by caſting a ſmall quantity into a ſpherical or elliptical ſegment, as in the bottom of an Iron ladle: from hence he conjectures, that the ſound of the ſonorous metals might be improved, for the bells of clocks, *&c.* by giving them a ſimilar form.

(*h*) *Fuſibility of Lead.*] It melts a little later than Tin or Biſmuth; much ſooner than any other metal; about the five hundred and fortieth degree of Fahrenheit's thermometer. The plumbers caſt thin ſheets of Lead upon a table or mould, covered with a woollen and above this a linen cloth, without burning or ſcorching the cloths. The melted Lead is received in a wooden caſe without a bottom, which being drawn down the ſloping table by a man at each ſide, leaves a ſheet, of its own width, and more or leſs thin according to the greater or leſs celerity of its deſcent.—For thick plates, the table is covered with moiſtened ſand, and the liquid metal conducted evenly over it, by a wooden ſtrike which bears on a ledge at each ſide.

LEAD.

Shot.

made uſe of. It is formed into round granules of ſhot, by pouring the melted Lead into cold water, through a perforated plate; a little Orpiment being added to the metal in fuſion; this improves its hardneſs, and makes it run more regularly into globules without drawing a tail.

Calcination.

Lead, when juſt become fluid, looks bright like Quickſilver; but preſently contracts on the ſurface a variouſly coloured powdery pellicle. Some have ſuppoſed that this was an heterogeneous ſubſtance; and that the Lead, by its ſeparation, became purer. But after this imaginary purification, it will ſtill, upon continuing the fire, exhibit a pellicle as at firſt: if this is taken off, or the metal ſtirred, ſo as to expoſe a freſh ſurface to the air, a new one will ariſe, till by degrees the whole quantity is changed into a duſky powder or calx, called *plumbum uſtum*. The injection of a little fat, charcoal powder, or other inflammable matters, prevents this change, and readily revives the calx into Lead again, notwithſtanding Boerhaave's aſſertion that the calx of Lead is very hard to reduce *(i)*.

Revival of the Calx.

Calx

(i) Calx of Lead revived.] The calces and the glaſs of Lead are extremely eaſy of revival; more ſo than thoſe of any other metal.

Common Flint glaſs contains a large proportion of vitrified Lead: I have extracted from it one fourth its weight of perfect malleable Lead. If a piece of this glaſs be ſurrounded in a crucible with Soot, powdered Charcoal, or other like inflammable matters, and cemented for ſome time with a fire inſufficient to melt it, the Lead will be revived throughout the whole internal ſubſtance of the glaſs, into little drops. If the matter is brought into fuſion, the Lead ſubſides, collected into one button at the bottom. This experiment affords a remarkable inſtance, not only of the eaſy reducibility of Lead, but of the penetrability of Glaſs, a ſubſtance which is looked upon as impervious to all kinds of fumes. I have ſeen innumerable globules of Lead thus revived in the middle of glaſs-ſtoppers above an inch thick, without the leaſt viſible crack or eroſion of the ſurface.

Wafers are coloured red by the red calx of Lead called Minium. On holding a Wafer barely in the flame of a candle, its Lead is preſently reduced, and runs down in drops.

The calces and glaſs of this metal abſorb the inflammable principle even from ſome other metallic bodies. If glaſs of Lead be melted in an Iron veſſel, or ſtirred in fuſion with an Iron rod, great part of the Lead will reſume its metallic form, a proportionable quantity of the Iron ſcorifying.

It

LEAD.

Maſticot and Minium.

Calx of Lead expoſed to the fire in a furnace ſo contrived as that the flame may play upon its ſurface, becomes white, yellow, and at length of a bright red colour; hence the yellow Lead or Maſticot, and the red Lead or Minium of the painters. Some ſuppoſe the converſion of Lead into Minium to be an effect of ſimple calcination, produced by the heat acting through the ſides of the veſſel; but no degree of heat will change the calx to a red colour, without the immediate contact of ſmoky flame. The metal acquires, in this operation, an increaſe of its weight, nineteen pounds of Lead yielding twenty pounds of Minium. —— The largeſt quantities of Minium are made at Venice, and in England. The Venetians employ for the beſt ſort, called *minio fine*, Ceruſſe or white Lead; for the middling ſort, *minio meſan*, the refuſe plates of Lead remaining after the making of Ceruſſe; the worſt kind, *minio ordinaire*, is prepared from Litharge (*k*).

Litharge.

If Lead be urged with a bright red heat, it changes by degrees into a yellow, flaky ſcoria, called Litharge, of a paler or deeper colour according to the degree of fire it has undergone. The paler ſort is diſtinguiſhed by the name of Litharge of Silver, the darker by that of Litharge of Gold; though neither of them contains any portion of theſe metals (*l*).

It is ſaid, that Lead, recovered from its calces, proves ſomewhat harder and whiter than at firſt, and leſs ſubject to tarniſh in the air. The difference, if any, is certainly very ſmall.

(*k*) *Minium.*] Minium is commonly prepared from Lead calcined into a greyiſh powder, by keeping it melted over the fire. This powder, ground in mills, is further calcined, in a reverberatory furnace, under a low arch, and frequently ſtirred with an Iron rake, to prevent its melting and running into clots, and to expoſe a freſh ſurface to the action of the air and flame. The calcination laſts two or three days. The increaſe of weight is ſaid to amount to one fourth the weight of the Lead; and the Lead recovered from the Minium to be one twentieth leſs than the original weight of the metal. If the Minium be further calcined, the increaſe is no more; but the quantity of Lead recoverable proves leſs in proportion to the vehemence and continuance of the calcination.

(*l*) *Litharge.*] The deep coloured Litharge is the moſt perfect ſort: the pale contains a conſiderable portion of Lead in its metallic ſtate, or uncalcined, and hence is never to be employed for ſuch operations

LEAD.

Glaſs of Lead. All the calces and ſcoriæ of Lead vitrify more eaſily than thoſe of any other metal: expoſed to a moderately ſtrong fire, they quickly run into a tranſparent yellow glaſs. This glaſs, in fuſion, powerfully diſſolves and vitrifies the more refractory metallic calces and earths; and unleſs ſaturated with theſe kinds of additions, corrodes and ſinks through the common crucibles (*m*).

Purification of Gold and Silver by Lead. If Gold or Silver be mixed with Lead, and expoſed to the fire, the Lead ſcorifies, as it would by itſelf, and ariſes to the ſurface, ſo as to be raked off in the form of Glaſs or Litharge; at the ſame time carrying with it any imperfect metal that the Gold or Silver had been mixed with, but leaving thoſe perfect metals themſelves unhurt. Hence Gold and Silver are purified by means of Lead from admixtures of the baſer metals; and hence Lead is called by the chemiſts, *balneum ſolis & lunæ*, *lavacrum regis & reginæ*, *ſapo metallorum*, &c.—The Litharge met with in the ſhops is produced in thoſe works where Gold and Silver are thus purified; and contains the heterogeneous metals which the Gold or Silver had been mixed with.

Silver produced from Lead. If Glaſs of Lead be reduced into Lead, and the revived Lead ſcorified again, there commonly remains a ſmall grain of Silver. If the Glaſs produced in this operation be again revived, another granule of Silver will be left upon a ſecond ſcorification. There is

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as demand a true calx or ſcoria of Lead. Even the higheſt coloured Litharge is ſeldom free from a little metallic Lead; diſcoverable and ſeparable, by melting the maſs in a crucible, when the Lead ſubſides to the bottom.

(*m*) *Glaſs of Lead — diſſolves earths, &c. in fuſion.*] Hence the uſe of Lead in vitrifications; whether for procuring a fine tranſparent glaſs, or for bringing refractory minerals, that participate of Gold or Silver, into thin fuſion, in order to the ſeparation of thoſe metals. The glaſſes made with it are ſoft: and hence its unfitneſs as a baſis for paſte and artificial gems, though it anſwers extremely well in point of tranſparency, luſtre, and beauty of the colours. It is obſervable, that calces of Lead diſſolve or vitrify ſand very eaſily, but clay very difficultly; hence crucibles, in whoſe compoſition ſand is an ingredient, are the ſooneſt corroded by them. Calces of Iron, on the contrary, render clay fuſible, and ſand refractory.

is a certain experiment, in which, by gradually taking away from the mercurial earth, and adding to the inflammable and vitreſcible, greateſt part of Lead is [ſaid to be] convertible into Silver.

Calcination with Tin.

Lead, mixed with Tin, calcines ſooner than by itſelf: one pound of Tin quickly incinerates ten pounds of Lead (*n*). With Arſenic it runs into a hyacinth

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(*n*) *Lead with other metals.*] Lead mingles in fuſion with all the metals except Iron; with which it refuſes any degree of union, ſo long as the Lead preſerves its metallic form. On continuing the fire, the Lead, ſcorifying or calcining, abſorbs the phlogiſtic principle of the Iron, and conſequently promotes the calcination of that metal: both being at length reduced into calces, the fuſible ſaturnine calx diſſolves the chalybeate into an opake brown or blackiſh Glaſs.

Copper does not unite with melted Lead, till the fire is raiſed ſo high as to make the Lead boil and ſmoke, and of a bright red heat: pieces of Copper now thrown in ſoon diſſolve and diſappear in the Lead: the mixture, when cold, is brittle, and its fracture of a granulated texture. The union of theſe two metals is remarkably ſlight: on expoſing the mixture to a fire, no greater than that in which Lead melts, the Lead almoſt entirely runs off by itſelf; a ſeparation, of which we do not know one other example. What little Lead is retained in the pores of the Copper, may be ſcorified and melted out by a fire conſiderably leſs than is ſufficient to make Copper flow. If any of the Copper is carried off by the Lead, it ſwims unmelted upon the ſurface, ſo as to be eaſily ſcummed off. The coarſer ſorts of Lead, which owe their brittleneſs and their granulated texture to an admixture of Copper, throw up their Copper in the ſame manner, on being melted by a ſmall heat, and thus become ſoft and malleable.

Tin unites very eaſily with Lead, into a compound more fuſible than Lead by itſelf, and which is hence employed as a ſolder for Lead. In point of malleability, Lead, of all the metals, ſuffers the leaſt from Tin, becoming only a little more hard. The metal, commonly made uſe of for organ-pipes, is ſaid to be compoſed of twelve parts of Lead and one of Tin.

Gold and Silver are diſſolved by melted Lead in a ſlight red heat. They are both rendred extremely brittle by the minuteſt quantity of Lead; though Lead is rendered more ductile by a ſmall quantity of either of them.

The affinities of Lead to different metals are very remarkable. In cupellation, a portion of it is retained by Gold, but Silver parts with it all. On the other hand, in its eliquation from Copper, if the Copper contains either of the precious metals, the Silver will totally melt out with the Lead, but Gold will not. The attraction of Lead to Copper, however ſlight, is greater than that of Copper to Iron: a mixture of Copper and Iron being boiled in melted Lead, the Copper is imbibed by the Lead, and the Iron thrown up to the top. Silver is in like manner imbibed from Iron by Lead, whilſt Tin, on the contrary, is imbibed from Lead by Iron. If two mixtures, one of Lead and Tin, and another of Iron and Silver, be melted together, the reſult will be two new combinations, one of the Tin with the Iron at the top, the other

LEAD.

Hyacinth Glaſs with Arſenic. Expoſed to a burning-glaſs.

hyacinth coloured extremely fuſible Glaſs; but Sulphur, which promotes the fuſion of many of the metals, renders Lead remarkably difficult of fuſion. Lead, expoſed to the focus of Tſchirnhaus's burning lens, firſt ſmokes, then looks like melted Reſin, and at length changes into a ſoft, yellowiſh, greeniſh, and reddiſh Glaſs.

Solution in the nitrous acid.

Lead diſſolves in the nitrous Acid into a yellow liquor; the ſolution inſpiſſated, explodes or fulminates in the fire (*o*). The marine acid, added to the ſolution,

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other of the Lead with the Silver at the bottom: how carefully ſoever the matter be ſtirred and mixed in fuſion, the two compounds, when grown cold, are found diſtinct, ſo as to be parted with a blow. The affinities or attractions of metals to one another are no-where more conſpicuous, nor the ſeparations depending upon them more perfect, than in theſe examples.

(*o*) *Menſtrua of Lead.*] Proof Aqua fortis, lowered with an equal quantity of water, diſſolves about half its weight of Lead. On diluting the ſolution with a large quantity of water, it turns milky, and depoſites the metal. The ſolution ſhoots, upon exhaling a part of the menſtruum, into ſmall pyramidical cryſtals with ſquare baſes, of an auſtere ſweet taſte.

In the memoirs of the French Academy for the year 1733, there is a particular account of an experiment, in which Mercury is ſaid to have been extracted from Lead by diſſolving it in the nitrous acid. During the diſſolution there fell a Precipitate, which is plainly proved to be Mercury, and which is looked upon as one of the conſtituent principles of the Lead, ſeparated by this ſimple proceſs. Probably the Aqua fortis made uſe of in this experiment had been impregnated with Quickſilver: in ſuch caſe the Mercury precipitates in proportion as the Lead diſſolves; but pure Lead, diſſolved in pure Aqua fortis, gives no ſuch Precipitate.

Spirit of common Salt, concentrated or diluted, has little or no effect upon Lead by moderate digeſtion. On raiſing the fire, ſo as to make the liquor boil and diſtill, the Lead retains a portion of the acid, and is corroded into a ſaline maſs, ſoluble, by a repetition of the proceſs, into a limpid liquor. When Lead is precipitated from Aqua fortis by Sea-ſalt or its acid, an addition of Aqua regia rediſſolves the calx, and Sea-ſalt no longer occaſions any precipitation.

Oil of Vitriol, aſſiſted by a boiling heat, corrodes about half its weight of Lead into a ſaline maſs. This acid, added to ſolutions of Lead, made in either of the others, imbibes the metal from them, and forms with it an indiſſoluble concrete, which falls to the bottom.

Cauſtic alcaline lixivia, boiled on plates of Lead, diſſolve a ſmall portion, and corrode a conſiderable quantity: the ſolution ſtains hair black. Lead, fuſed with fixt alcaline Salts, is in part corroded into a dark-coloured ſcoria, which partially diſſolves in water.

Expreſſed Oils diſſolve calces of Lead, by boiling in ſuch large quantity as to become thick or conſiſtent: hence Plaſters, cements for water-works, paint for preſerving nets, *&c.*

Acids

Saturnus Corneus.

Cauſtic ſpirit from Sal Ammoniac.

ſolution, precipitates the Lead in the ſame manner as it does Silver. And the Precipitate, like the combination of the ſame Acid with that metal, has, when melted, ſome degree of flexibility and tranſparency, ſomewhat reſembling horn; whence its name *Saturnus Corneus.* If Lead or Minium be mixed with Sal Ammoniac and expoſed to the fire, the volatile alcali of the Salt is extricated, and its acid abſorbed by the Lead. The ſpirit which diſtils on this occaſion, like that prepared by Quicklime, is extremely volatile and cauſtic, and yields no concrete Salt. Its quantity is but ſmall.

Ceruſſe.

Lead expoſed for ſome time to the ſteam of Vinegar or other vegetable acids, is gradually corroded into a white calx, which is the Ceruſſe or white Lead of the ſhops. The beſt ſort of Ceruſſe is in large thick flakes: the powder ſorts are commonly adulterated with an admixture of Chalk or whiting. The greateſt quantities are made at Venice, Amſterdam, and in England.

Solution in Vinegar.

Saccharum Saturni.

Vegetable acids diſſolve Lead in its metallic ſtate very difficultly and ſparingly; its calces more readily, though the quantity of theſe taken up is very ſmall. A drachm of Litharge requires for its ſolution eight ounces of diſtilled Vinegar, and a drachm of Minium as much again. Out of a drachm of Lead itſelf, two pounds of Vinegar will hardly diſſolve a ſcruple. The ſolution is of a ſweet taſte; and if duly evaporated, and ſet in a warm place, that the remaining moiſture may ſlowly exhale, yields cryſtals, called, from their ſweetneſs, *Saccharum Saturni*, Sugar of Lead.

On diſtilling the *Saccharum Saturni* in a retort, there ariſes an inflammable ſpirit, which is ſuppoſed to be Spirit of Wine reſuſcitated from the Vinegar; though it has not the taſte of vinous ſpirits. This

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Acids have a greater affinity with Lead than Oils have. If the common plaſter, compoſed of Oil and Litharge, be boiled in diſtilled Vinegar, the Litharge will be diſſolved, and the Oil thrown up to the ſurface. The Oil thus recovered, proves ſoluble, like eſſential Oils in Spirit of Wine; a phœnomenon firſt taken notice of by Mr. Geoffroy.

is followed by a thin yellowiſh oil, and a thicker red one, eſpecially if the *Saccharum* has been made with undiſtilled Vinegar. From twelve ounces of the Sugar were obtained three and a half of oily liquor: the reſiduum weighed eight ounces and a half, and yielded on reduction ſeven and a half of Lead. Libavius and others pretend that an inflammable ſpirit may be obtained from a ſolution of Lead in the vitriolic acid diluted with water, filtered and inſpiſſated. But though the experiment was often with great care repeated and varied, no inflammable liquor was produced.

Uſes of Lead.

Lead is employed for various mechanic uſes; as in thin ſheets for covering buildings, for pipes, ſtatues, ſhot and bullets, windows, for ſecuring iron bars in hard ſtones, for ſundry kinds of large veſſels for evaporation, *&c.* It has been obſerved that plants do not thrive ſo well in leaden, as in earthen and wooden veſſels. —— Its principal uſes in the chemical arts are, for promoting the vitrification of earthy and ſtony matters, in the making of Glaſs, or in the ſmelting of ores, or in the glazing of earthen veſſels; for the refining of Gold and Silver; for the eliquation of Silver from Copper; for forming with oil the baſis of varniſhes and paints.

Medical hiſtory of Lead.

The effects of Lead on the human body are dangerous: thoſe who are expoſed to its vapours in the fire, and even thoſe who grind its calces, Minium, Ceruſſe, and Litharge, for the painters, are ſubject to violent gripes and conſtipations of the bowels, contractions of the limbs, and other diſorders. Much more hurtful is the internal uſe of Lead corroded or diſſolved by acids, as *Ceruſſe*, *Saccharum Saturni*, the ſolution in Vinegar called *Acetum Lithargyrii*, or the tincture drawn from the *Saccharum* with Spirit of Wine, commonly called *Tinctura Antiphthiſica*. The ſaturnine preparations are applied externally with ſafety, as coolers, repellents, and deſiccatives. Its calces, diſſolved in oils, form the baſis of moſt of the officinal plaſters.

Culinary veſſels, lined with a mixture of Tin and Lead, which is the uſual tinning, are apt to communicate to acid foods pernicious qualities, and require to be uſed with great precaution. — In Holland, and perhaps in other places, it has been cuſtomary to correct the more offenſive expreſſed Oils, as that of rape-ſeed, ſo as to ſubſtitute them to oil Olive or oil of Almonds, by impregnating them with Lead. This dangerous abuſe may be diſcovered, by mixing a little of the ſuſpected oil with a ſolution of Orpiment made in Lime-water. On ſhaking them together, and ſuffering them to reſt, the oil, if it has any ſaturnine taint, will appear of an orange-red colour; if pure, of a pale yellowiſh. — The ſame abuſe has been extended alſo to acid wines, which diſſolve ſo much Lead as to acquire a ſweet taſte, and to become ſlow poiſons. The Lead is readily diſcovered in theſe likewiſe by the ſame ſulphureous ſolution; which changes the colour of wines impregnated with this metal to a browniſh red or blackiſh; Lead, whether diſſolved or in its metallic form, being conſtantly ſtained by ſulphureous liquors or vapours.

Method of diſcovering Lead in liquors.

Lead is ſometimes found in the earth native or in its metallic form, though very rarely pure. Its common ores are nearly of the colour of Lead itſelf, and appear compoſed of cubes or parallelopipeds, ſometimes large and regular, ſometimes irregular and ſmall. There are Lead ores alſo of a white, greyiſh, or greeniſh colour, and priſmatic figure; but theſe are rarely met with (*p*). The ores of Silver,

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(*p*) *Lead Ores.*] Lead is exceeding rarely, if ever, found native in the earth. The maſſes, which have been taken for native Lead, appear, upon due examination, to be the malleable leaden coloured ores of Silver. — The common Lead ores conſiſt of Lead in the ſtate of a calx, blended with Sulphur. Minium, Litharge, or other calces of Lead, melted with Sulphur, form a compound ſimilar to them both in appearance and quality.

The ores of Lead ſoften, in a moderate red heat, into the conſiſtence of a paſte, but do not flow thin in a ſtrong fire. If Iron filings are mixed, the Iron abſorbs the Sulphur, and at the ſame time revives the Lead into its metallic form. This is one of the moſt commodious

LEAD.

ver, Copper, and other metals except Tin and Iron, have often a Lead ore intermixed. The Lead is extracted by fuſion in contact with the fuel. The furnace being ſufficiently heated with wood or charcoal, the powdered ore is thrown in by degrees, and freſh fuel and ore occaſionally ſupplied. The Lead, revived by the inflammable matter of the coals, runs down into a baſon at the bottom of the furnace; from whence it is laded out, and caſt in Iron moulds, into large maſſes called pigs of Lead. All the common Lead ores contain ſome Silver. The ſteel-grained, and ſuch as are compoſed of ſmall cubes, have generally more Silver than the compact and large-diced ſorts: the white and green ſcarcely hold any. The Silver is extracted, when its quantity is conſiderable enough to bear the expence of extracting it, by ſcorifying the Lead upon a teſt. The whole being kept in fuſion on a hearth made of bone-aſh or other like materials, the Lead partly vitrifies, and ſinks into the hearth, and partly turns to Litharge, which floats on the ſurface, and is raked or blown by bellows to one ſide; the Silver at length remaining by itſelf. Lead almoſt always contains ſome portion of Copper; and hence the Silver obtained in this operation is ſcarcely ever free from ſome admixture of that metal. If the pureſt Silver be cupelled or teſted with Lead, it will gain from the

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modious methods of ſmelting Lead ores, where the operation is performed in veſſels. Mr. Scheffer informs us, that the Lead ores at Dal in Sweden, containing from twenty to twenty-five ounces of Silver on the hundred pounds, are ſmelted by this method, in crucibles, without any loſs of the Silver; and that the produce of Lead is greater than that obtained by other means. The aſſayers generally calcine the ore, to diſſipate the Sulphur, and then melt it with twice or thrice its weight of black flux; ſuſpecting, that as the ſcoria, when only Iron is uſed, does not melt, a little of the Lead may be retained in it. The yield of Lead is from about one third to upwards of two thirds of the weight of the ore: according as it is leſs or more free from ſpar or other heterogeneous earthy matters.

The white or greyiſh, and the yellowiſh green ores are very rarely met with, and their compoſition is little known. They are very ponderous, and very rich in metal. On barely expoſing them to the flame of a candle, the Lead quickly and plentifully melts out. They are ſometimes cryſtalline and ſemitranſparent; ſometimes opake, and little different in appearance from common ſtones.

LEAD.

the Lead a venereal taint; a ſmall proportion of Copper being defended by the Silver from ſcorifying along with the Lead *(q)*.

II. COPPER.

COPPER.

General Characters

COPPER, *Venus*, is a reddiſh metal, eaſily tarniſhing in a moiſt air, and contracting a green or a bluiſh green ruſt. It is the moſt elaſtic and ſonorous of all the metals, and the hardeſt of all but Iron *(r)*. It ſpreads difficultly under the hammer, but may be extended to a great degree; drawn into fine wire, and beat into thin leaves. Its ſpecific gravity is near nine times greater than that of water.

Fuſion.

It requires for its fuſion a ſtrong white heat; greater than that in which Gold and Silver melt, though not ſo great as that which is requiſite for the fuſion

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(q) *Lead contains*, &c.] Almoſt all the common ſorts of Lead contain a portion of Silver, too inconſiderable to be extracted to any advantage, but large enough to deſerve attention in the nicer chemical experiments. In aſſaying particularly, where Lead is often employed in eight, ten, twelve, or more times the quantity of the ore or metallic mixt to be examined, its purity from the precious metals is of primary conſequence; leſt we aſcribe to the ore, the Silver furniſhed by the ſuperadded Lead. For the greater certainty in this point, the Lead is aſſayed ſeparately. Thus when a Silver ore is to be ſcorified by Lead, an equal quantity of the ſame Lead is at the ſame time ſcorified by itſelf; and the weight of the button of Silver, left by the Lead, deducted from that left by the ore and Lead.

Lead, revived from perfect Litharge, is pure from the precious metals; theſe metals not being convertible with it into that form. Litharge diſſolves in Aqua fortis, and is precipitated by oil of Vitriol; and in theſe properties differs from all other metallic calces. Hence by edulcorating the Precipitate with freſh parcels of boiling water, and reviving it with inflammable fluxes, we obtain Lead perfectly pure from all other known bodies.

(r) *Copper — hard*, &c.] Copper in ſome of its ſtates is as difficultly extended under the hammer as Iron, but proves ſofter to the file; and is never found hard enough to ſtrike a ſpark with Flint or other ſtones; whence its uſe for chiſſels, hammers, hoops, &c. in the gun-powder works. Broke, by often bending backwards and forwards, it appears internally, of a dull red colour without any brightneſs, and of a fine granulated texture; not ill reſembling, as Cramer obſerves, ſome kinds of earthen ware. The ſpecific gravity of the fineſt Copper I have been able to procure, turned out to that of water as 8,830 to 1,000.

COPPER. fuſion of Iron (*s*). When melted, it is remarkably impatient of moiſture. The contact of a little water occaſions the melted Copper to be thrown about with violence, to the great danger of the by-ſtanders. It may nevertheleſs be granulated, like other metals, by cautiouſly pouring a very little at a time into water (*t*).

Calcination.

Kept in a heat below fuſion, it contracts on the ſurface thin powdery ſcales, which, if rubbed off, are ſucceeded by freſh ones, till the whole quantity of the metal is thus ſlowly changed into a dark reddiſh ſcoria or calx. This does not melt in the greateſt degree of fire that our furnaces are capable of giving; but in the concentrated ſolar heat, it runs eaſily into a deep red and almoſt opake Glaſs. A flaming fire, and a ſtrong draught of air over the ſurface of the metal, promote its calcination. The flame being tinged of a green, bluiſh, or rainbow colours, is a mark that the Copper burns.

Vitrification.

Solubility in different liquors.

Copper diſſolves in every acid, in alcalies both fixed and volatile, in neutral ſaline liquors, and in oils; and when diſſolved, exhibits fine blue, green, or bluiſh-green colours, by which this metal is readily diſtinguiſhed, however mixed or diſguiſed with other ſubſtances

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(*s*) *Copper in the fire.*] Copper continues malleable when heated red, and in this ſtate extends more eaſily than when cold. In this reſpect it agrees with Iron; but it wants that valuable quality of Iron, by which two pieces cohere when heated, ſo as to be welded or joined into one. When in fuſion, it appears on the ſurface of a bluiſh-green colour, nearly like that of melted Gold. Kept in fuſion for a length of time, it becomes gradually more and more brittle, but does not ſcorify conſiderably, nor loſe much of its weight. It is much leſs deſtructible than any of the other imperfect metals, and is very difficultly ſubdued even by Lead or Biſmuth.

(*t*) *Granulation.*] Copper is ſaid to be granulated in the braſs-works at Briſtol, without exploſion or danger, by letting it fall, in little drops, into a large ciſtern of cold water covered with a braſs-plate. In the middle of the plate is an aperture, in which is ſecured, with Sturbridge clay, a ſmall veſſel, whoſe capacity is not above a ſpoonful, perforated with a number of minute holes, through which the melted Copper paſſes. A ſtream of cold water is kept conſtantly running through the ciſtern. If ſuffered to grow hot, the Copper falls liquid to the bottom, and runs into plates.

ſtances (*u*). Even pure water, ſuffered to ſtand long in copper veſſels, extracts ſo much as to gain a coppery taſte. It is obſervable, that water becomes more impregnated with the taſte on ſtanding in the cold, than if boiled in the veſſel for a longer time (*x*).

Copper.

Phœnomena in treating it with different acids.

The nitrous acid diſſolves Copper the moſt readily and plentifully. The ſolution is of a green colour.

The marine acid acts more languidly (*y*). The ſolution made in this acid yields, on being inſpiſſated, a greeniſh maſs, which readily diſſolves in water, deliquiates in the air, gives a green tincture to rectified Spirit of Wine, melts in a ſmall heat, takes fire from a candle, and burns with a blue flame. The marine acid forſakes Mercury to unite with Copper. On expoſing to the fire a mixture of Copper and Mercury ſublimate, the acid of the ſublimate forms with the Copper a fuſible inflammable concrete ſimilar to the foregoing, whilſt the Mercury, diſengaged, diſtils in its running form.

The vitriolic acid does not eaſily diſſolve Copper, unleſs highly concentrated and aſſiſted by a conſiderable heat: the ſolution is of a blue colour; and, on evapo-

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(*u*) *Diſtinguiſhed by its colour in ſolution.*] The colour of Copper is moſt conſpicuous with volatile alcaline ſpirits. Solutions made in acids, when conſiderably diluted, have little colour. The addition of volatile ſpirits to the almoſt colourleſs liquor renders it inſtantly of a deep blue. The hundredth part of a grain of Copper, diſſolved in a pint of liquor, ſtrikes a ſenſible blue with volatile alcalies.

(*x*) *Corroded more by cold than by boiling water.*] The caſe ſeems to be the ſame in regard to the mild vegetable acids. The confectioners prepare the moſt acid ſyrups, even thoſe of Orange and Lemon-juice, by boiling in clean copper veſſels, without the preparations receiving any ill taſte from the metal; whereas either the juices themſelves, or the ſyrups made from them, if kept cold in copper veſſels, ſoon become impregnated with a diſagreeable taſte, and with the pernicious qualities of Copper.

(*y*) *Solution in the marine acid.*] This ſolution, if made without heat, appears at firſt brown, but on ſtanding for ſome time, depoſites a white ſediment, and becomes green. On adding freſh Copper, it turns brown again, and now recovers its greenneſs more ſlowly than at firſt. The white ſediment is not, as ſome ſuppoſe, a part of the metal deprived of its colouring principle. On being barely melted, it proves pure and perfect Copper, of the ſame red colour as at firſt.—— Copper, calcined by fire, communicates to this acid not a green but a reddiſh tincture.

COPPER. evaporating a part of the humidity, ſhoots into elegant blue cryſtals of a rhomboidal figure: theſe are the blue Vitriol of the ſhops. The ſolution is moſt commodiouſly obtained, by drawing over the oil of Vitriol from the Copper, and elixating the reſiduum with water; then returning the diſtilled ſpirit upon the undiſſolved Copper, and repeating the abſtraction; or by ſtratifying the Copper with Sulphur, in a crucible, and calcining or cementing them together; the Copper will abſorb the acid of the Sulphur, ſo as to become in part ſoluble in water, and yield the ſame cryſtals as if the metal had been boiled directly in the vitriolic acid.

Volatile alcalies, added to the ſolutions made in acids, occaſion at firſt ſome precipitation, but preſently rediſſolve what they had thrown down, and change the colour, from a green or a pale blue, to a deep and lovely blue: if the liquor is expoſed for a time to the air, the volatile alcali eſcapes, and the colour which proceeded from it diſappears. Volatile alcalies extract a blue tincture alſo from filings of the metal, without the intervention of any acid (z).

Verdegris. Vegetable acids diſſolve Copper ſlowly, but in conſiderable quantity: the ſolution ſhoots into bluiſh green cryſtals, ſimilar to the Verdegris, *ærugo* or *viride æris*, of the ſhops. This preparation is made in large quantity in France, particularly about Montpelier, by ſtratifying copper-plates with the huſks of grapes remaining after the juice has been preſſed out: theſe ſoon become acid, and corrode the Copper.

(z) *Volatile alcalies.*] The blue mixture of ſolution of Copper in Aqua fortis with volatile ſpirits, yields ſapphire coloured cryſtals, which diſſolve in Spirit of Wine, and impart their colour to it. If, inſtead of cryſtallization, the liquor be totally evaporated, the remaining dry matter explodes in a moderate heat, like Aurum Fulminans. The ſolution made in volatile alcalies, without the intervention of any acid, yields, on evaporation, a blue ſaline maſs, which, mixed with fats or other inflammable matters, tinges their flame green, leaving a red calx of Copper ſoluble in volatile ſpirits again as at firſt.——Boyle obſerves, that volatile ſpirits gain no tinge from Copper in vacuo; whether it is the diſſolution of the metal, or only the colour, that does not ſucceed without air, has not been fully determined.—Oil of Vitriol added to the blue ſolutions, deſtroys their colour; a freſh addition of volatile Alcali recovers it again.

Verdegris ſhould be choſen in cakes, not moiſt or unctuous, but dry, compact, and of an uniform texture, of a lively green colour throughout, as free as poſſible from white or black ſpecks, and ſeeds or ſtalks of the grape. It is purified by ſolution in diſtilled Vinegar, and cryſtallization; and then called, improperly, *diſtilled Verdegris*, or *flowers of Copper.* The Dutch, who prepare theſe cryſtals in large quantity, after duly evaporating the ſolution, ſet it to ſhoot, not, as is cuſtomary, in a cold, but in a warm place, as practiſed for making Sugar-candy. If rectified Spirit of Wine be added to the ſolution, or if volatile alcalies be added to a ſolution of Copper and Spirit of Wine to this mixture, ſmall blue cryſtals will be immediately formed: theſe are called, by ſome, antepileptic cryſtals of Copper.

Divers experiments on Verdegris.

Highly rectified Spirit of Wine, digeſted on half an ounce, or twelve ſcruples, of powdered Verdegris, diſſolved three ſcruples and a half; ordinary rectified Spirit, four ſcruples; common Malt Spirits, four and a half; and French Brandy, ſeven and a half. Water diſſolved, out of the ſame quantity, five ſcruples; common Wine Vinegar diſſolved all but fifteen grains; and diſtilled Vinegar, all but ten grains *(a)*. The whole quantity of Verdegris diſſolved in either kind of Vinegar, could not be recovered again in a cryſtalline form; from the common Vinegar, only two ſcruples and five grains cryſtallized; and from the diſtilled Vinegar three ſcruples: the reſiduum, in the firſt caſe, continued ſoftiſh, in the latter dry. With French Brandy there was no cryſtallization at all; the whole that the ſpirit had taken up, remaining uniformly mixed, into the conſiſtence of an extract.

(a) Reſiduum of Verdegris.] ' The matter which diſtilled Vinegar leaves undiſſolved, on being mixed with ſome Borax and Linſeed-oil, and fluxed in a crucible, yields a brittle metallic ſubſtance, of a whitiſh colour, not unlike bell-metal. What this metal really is, has not hitherto been examined.

COPPER.

Verdegris, diſtilled in a retort, yields a concentrated acetous acid. Mr. Serane relates that, from ſixteen ounces of cryſtallized Verdigris, he obtained three ounces of phlegm, and afterwards ſix ounces of ſtrong ſpirit; that the brown powdery reſiduum weighed five ounces and a half, and yielded, on fuſion with Borax, three ounces and ſix drachms of Copper. Lanciſi mentions alſo this experiment, and ſeems to have borrowed it from Serane, the quantities being exactly the ſame, except that only the drachms of Copper are put down, the ounces being by miſtake omitted. I repeated the proceſs, with the ſame quantity of Verdegris, and gained four ounces of phlegm, two ounces of ſpirit of moderate ſtrength, three ounces and ſix drachms of ſtrong ſpirit, and ſix ounces two drachms of reſiduum.

The ſpirit thus obtained is no more than the concentrated acid of Vinegar. Zwelffer prepares a ſpirit which is ſaid to be different. Cryſtallized Verdegris is reduced into groſs powder, put into a glaſs retort, with ſo much highly rectified Spirit of Wine as will cover it to the height of three or four fingers, the vinous ſpirit drawn off, and a freſh parcel returned two or three times; the remaining Verdegris is then diſtilled in a coated retort in an open fire, and the acid ſpirit which ariſes, rectified by a ſecond diſtillation in a freſh retort. Boerhaave relates, that this ſpirit loſes its acidity, in the ſame manner as other acids, when combined with alcalies or abſorbents, and that the pure acid is never to be recovered again from thoſe admixtures. Stahl, on the other hand, confirms Zwelffer's account, that this ſpirit differs from the common acetous acid, in being recoverable from abſorbent earths, as ſtrong as at firſt; and this repeatedly for any number of times. My experiments have not as yet been carried far enough to determine this point; but it appears probable, that Boerhaave, inſtead of Zwelffer's ſpirit, employed common ſpirit of Verdegris. From four ounces of dried cryſtals of Verdigris I abſtracted two parcels of highly rectified Spirit of Wine, and found that the Verdigris had then loſt ſix drachms of its weight; being now diſtilled in an open fire gradually increaſed, it yielded one ounce, five drachms, and two ſcruples of ſpirit: the reſiduum half an ounce and one ſcruple, and looked like Colcothar. The liquor, which came over about the middle of the diſtillation, had a very volatile penetrating ſmell; and the ſtronger ſpirit fumed at times like the ſmoking mineral ſpirits.

COPPER.

Almagation.

Quickſilver amalgamates very difficulty with Copper in its pure ſtate, but unites with it more eaſily if divided by certain admixtures. If Mercury and Verdegris be triturated together, with common Salt, Vinegar, and water, the Copper in the Verdegris will be imbibed by the Mercury, and form with it, as Boyle obſerves, a curious amalgam, at firſt ſoft, ſo as to receive any impreſſion, and which, on ſtanding, grows hard like brittle metals. Braſs leaf likewiſe gives out its Copper to Mercury, the other ingredient of the Braſs ſeparating in the form of powder *(b)*.

Compound metals with Copper.

Braſs.

Copper is the baſis of ſundry compound metals for mechanic uſes; as Braſs, Princes-metal, Bell-metal, Bath-metal, white Copper, &c. Braſs is prepared from Copper and Calamine, with the addition of powdered Charcoal, cemented together, and at length brought into fuſion: ſixty-four pounds of Copper commonly imbibe in this proceſs twenty-ſix pounds from the Calamine, and yield ninety of Braſs: the paler the Braſs, the more of the Calamine it holds. This

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(b) Amalgam of Copper.] I have likewiſe obtained amalgams of Copper, by grinding Quickſilver in an iron mortar, with a ſaturated ſolution of the metal in Aqua fortis, as alſo with the muddy ſubſtance procured in the poliſhing copper-plates, and by cautiouſly pouring a ſmall quantity of melted Copper, in a ſlender ſtream, through a perforated iron plate, into a large portion of Quickſilver made almoſt boiling hot. The Copper, recovered from the amalgams, retained its its original redneſs, and diſcovered no tendency to the yellow colour, which Homberg reports that this metal acquires on being amalgamated and freed from the Mercury. Even when Braſs is uſed for making the amalgam, the recovered metal is perfect red Copper; the ingredient, from which the Braſs received its yellowneſs, being, as above obſerved, ſeparated in the amalgamation.

Copper.

Princes-metal.

Bell-metal.

This metal, notwithſtanding its large admixture of a brittle metallic body, continues ſtill remarkably ductile: it is drawn into the fineſt wire, for muſical inſtruments, *&c.* and beat into leaves, in imitation of gold-leaf. The metallic part of the Calamine, which here unites with the Copper, appears to be Zinc: hence Braſs, expoſed to the fire, flames like Zinc itſelf, and, loſing by degrees that volatile ingredient, becomes Copper again (*c*). Princes-metal is made by melting Zinc in ſubſtance with Copper; and all the yellow compound metals prepared in imitation of Gold, are no other than mixtures of Copper with different proportions of that ſemi-metal, taken either in its pure ſtate, or in its natural ore Calamine, with an addition ſometimes of iron filings, *&c.* Zinc itſelf unites moſt eaſily with the Copper, but Calamine makes the moſt ductile compound, and gives the yelloweſt colour. Bell-metal is a mixture of Copper and Tin; though both theſe metals are malleable ſingly, the compound proves quite brittle (*d*). White Copper

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(*c*) *Braſs.*] The proportion of Calamine, and the increaſe the Copper receives from it, are different at different works: hence the deeper or paler colour of Braſs. I have obſerved, in a large ſet of experiments on this ſubject, that a little of the Calamine (that is, the Zinc contained in Calamine) dilutes the colour of the Copper, and renders it pale; that when the Copper has imbibed about one twelfth its own weight, the colour inclines to yellow; that the yellowneſs increaſes more and more till the proportion comes to almoſt one half; that, on further augmenting the Calamine, the Braſs becomes paler and paler, and at laſt white. The crucibles, in which the fuſion is performed in the large works, are commonly tinged by the matter of a deep blue colour.

Braſs is ſomewhat lighter, harder, and more ſonorous, than pure Copper. It melts more eaſily, and does not ſcorify ſo ſoon in a moderate red heat; and hence proves more convenient for ſundry ſorts of veſſels and utenſils. It is ductile only whilſt cold; heated a little, it cracks; ignited, it falls in pieces under the hammer. This imperfection it receives from the Zinc, pure Copper being malleable when hot as well as when cold.

(*d*) *Copper with Tin.*] Copper is diſſolved by melted Tin, eaſily and intimately; far more ſo than by Lead. A ſmall portion of Tin renders Copper dull coloured, hard, and brittle. Bell-metal is compoſed of about ten parts of Copper to one of Tin, with the addition, commonly, of a little Braſs or Zinc. A ſmall portion of Copper, on the other hand, improves the colour and conſiſtence of Tin, without much injuring its ductility. Pewter is ſometimes made from one part of Copper, and twenty or more of Tin.

COPPER.

White Copper.

Copper is prepared with Arſenic: equal parts of Arſenic and Nitre, pulverized and mixed together, are injected into a red-hot crucible, and kept in a moderate fire, till they ſubſide and flow like wax: one part of this mixture is injected upon four parts of melted Copper, and the metal, as ſoon as they appear thoroughly united together, immediately poured out. The Copper thus whitened is commonly melted with a conſiderable proportion of Silver, by which its colour is both improved and rendered more permanent (*e*).

Uſe in painting, &c.

Sundry preparations of Copper are employed in painting, ſtaining, and for colouring glaſs and enamels (*f*.) Verdegris makes a fine green both in oil and in water colours, inclining, more or leſs, to bluiſh:

It has long been obſerved, that though Tin is ſpecifically much lighter than Copper, yet the gravity of the compound, Bell-metal, is greater than that of Copper itſelf. I found the ſame augmentation of gravity alſo where the lighter metal was in greater proportion: a mixture even of one part of Tin with two of Copper turned out ſpecifically heavier than pure Copper.

From ſome experiments on other metals, which this remarkable phœnomenon gave occaſion to, it appeared that few metallic mixtures anſwer to the mean gravity of the ingredients, or ſuch as would reſult from a bare appoſition of parts. Of thoſe that have been tried, ſome exceeded the mean, but the greater number fell ſhort of it: Copper and Tin were the only ones that formed a compound heavier than the heavieſt of the metals ſeparately.

From theſe obſervations it is obvious, that Archimedes's propoſition, and the tables calculated on that principle, in the *Commentaria Petropolitana*, &c. for determining the proportion of two metals in a given mixt by hydroſtatical experiments, are leſs to be depended on than has hitherto been ſuppoſed.

(*e*) *White Copper.*] The white Copper of China and Japan appears to be no other than a mixture of Copper and Arſenic. Geoffroy relates, that, on repeated fuſions, it exhaled arſenical fumes, and became red Copper; loſing, with its whiteneſs, one ſeventh of its weight.—Copper is ſaid to be whitened alſo by cementation with the aſhes of Tartar imperfectly burnt: I have frequently cemented it with theſe, for different lengths of time, without being able to perceive the leaſt alteration in the colour of the Copper.

(*f*) *Staining, coloured Glaſs*, &c.] Solution of Copper in Aqua fortis ſtains Marble and ſome other ſtones of a green colour: precipitated with Chalk or whiting, it yields the green and blue verditer of the painters. A ſolution made in volatile ſpirits ſtains ivory and bones, macerated for ſome time in the liquor, of a blue colour, at firſt ſufficiently beautiful, but which tarniſhes in the air, and becomes green. I know of no method of obtaining by art a permanent blue from Copper,

Copper.

iſh: a ſolution of it in Aqua fortis, inſpiſſated, tinges Glaſs in fuſion of the ſame colour. In ſome parts of France, it is cuſtomary to mix Verdegris with Plaſter-of-Paris, which, by this means, is ſaid to become firmer and more durable. It is employed alſo in cements for heightening the colour of Gold: a mixture of Gold with one third, or even with half, its weight of Silver, is ſaid to acquire, on cementation with Verdegris, the colour of pure Gold. See Gold.

Medical Hiſtory.

The medical uſe of Copper is intirely external: Verdegris, and blue Vitriol, are employed as mild eſcharotics, for cleanſing fiſtulous ulcers, and other like purpoſes. Internally, all the preparations of this metal are extremely dangerous. Examples are too frequent of fatal conſequences from eating food that had received a taint from Copper-veſſels; whether from the food itſelf being of an acid nature, ſo as to corrode or diſſolve a portion of the metal; or from the veſſel having contracted a ſoluble ruſt or Verdegris by lying in the air: the utmoſt caution is therefore requiſite in the uſe of Copper-veſſels, and even of Silver ones that are largely alloyed with Copper. I knew a perſon, who, having accidentally ſwallowed a braſs ſleeve-button, was ſeized with violent ſymptoms, and died in miſery; no medicines giving relief. I have known vehement vomitings, and even convulſions, in children, from the *unguentum ægyptiacum*, whoſe baſis is Verdegris, applied to ulcers in the mouth: when employed in this intention, as it commonly is, the patient muſt be well upon his guard againſt any of it paſſing down.

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per, but by vitrification. I have prepared elegant deep blue glaſſes by melting common Glaſs, or compoſitions of powdered Flint and fixed alcaline Salt, with Verdegris, and with blue Vitriol, and with an amalgam of Copper; fine green ones, with green Verditer, with blue Verditer, with a Precipitate of Copper made by fixt alcalies, and a Precipitate by Zinc; and a reddiſh Glaſs, with calx or ſcoria of Copper made by fire alone. Even in this vitreous ſtate, however, it ſeems as if a continuance of fire had the ſame effect in regard to colour, as air has upon Copper in other forms. Some of the moſt beautiful blue glaſſes, by continued fuſion, changed to a green.

COPPER. Natural Hiſtory.

Copper is exceeding rarely found pure in the earth. Of its ores there is a great variety, intermixed with different ſtony matters, generally abounding with Sulphur, ſometimes containing a little Arſenic. Theſe ores are often of beautiful colours, blue, red, green, yellow, variegated like the rainbow or peacock's tail, moſt commonly green or blue: they are of all ores the moſt beautiful. The Lapis Lazuli, from which the precious blue pigment, called Ultramarine, is prepared, is one of the ores of this metal. Some of them contain no metal but Copper; many have an admixture of others; and there are few ores of other metals without ſome portion of Copper in them. Copper is of all metals the moſt difficultly obtained pure from the ore; Sulphur adhering to it ſo ſtrongly as not to be expelled without long calcination. When Copper and Iron are blended together in the ore, the Copper cannot, by any method as yet known, be ſeparated to advantage: a rich Copper-mine, at Lauterberg in the Hartz foreſt, lies on this account unworked.

There are ores of Copper in almoſt all parts of the world; in Spain, France, England, Norway, Saxony, Bohemia; but more particularly in Sweden, Hungary, and Tranſylvania. Japan affords a ſort of Copper ſuperior to any met with in Europe.

Copper is found alſo in a vitriolic ſtate, diſſolved in certain waters, as at Neuſol in Hungary. When Iron is put into the water, the diſſolved Copper ſeparates, a proportionable quantity of the Iron being diſſolved in its place. The Copper, extricated from the liquor, adheres to the Iron, and covers its ſurface with a bright cupreous coat: ſome have been ſo far impoſed on, as to imagine the iron, by this means, actually tranſmuted into Copper.

III. IRON.

IRON. Its general characters.

IRON, *Mars*, is a greyiſh metal, ſoon tarniſhing in the air to a duſky blackiſh hue, and in no long time contracting a yellowiſh or reddiſh ruſt. It is the moſt ſonorous of the metals except Copper; the hardeſt and moſt elaſtic of them all; hence its excellence for mechanic inſtruments. It is made into tools, by which all others are filed, drilled, and cut; and is the only one that ſtrikes ſparks with Flint. It ſpreads difficultly under the hammer, but may be extended to a great degree, drawn into wire as ſlender as the fineſt hairs: it is more eaſily malleable when ignited than when cold; whilſt ſome of the other metals, though ductile when cold, become quite brittle by heat. It is lighter conſiderably than Copper, and a little heavier than Tin. It is the only metallic body which attracts, or is attracted by, the magnet, one of its own ores.

Ignefcibility.

Iron grows red-hot much ſooner than any other metal, and this not only from the application of actual fire, but likewiſe from ſtrong hammering, friction, or other mechanic violence. It nevertheleſs melts the moſt difficultly of all the metals; requiring, in its moſt fuſible ſtates, an intenſe bright white heat. When perfectly malleable, it is not fuſible at all, without additions, or the immediate contact of the burning fuel; and when melted it loſes its malleability: all the common operations which communicate one of theſe qualities, deprive it, at the ſame time, of the other, as if fuſibility and malleability were in this metal incompatible.

Fuſibility,

Calcination.

Expoſed to a white heat, inſufficient for its fuſion, it contracts a ſemivitreous coat, which burſts at times, and flies off in ſparkles: no other metallic body exhibits any ſuch appearance (*g*). On continuing

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(*g*) *Iron, phænomena from fire.*] The contact of cold liquors occaſions Iron to ſcale in a ſmall degree of heat: hence its unfitneſs for boilers in ſuch works as require them to be emptied and charged again whilſt hot.

nuing the fire it changes by degrees into a dark red calx, which does not melt in the moſt vehement heat

Iron.

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It does not tinge the flame of burning matters bluiſh or greeniſh, like the other imperfect metals, but brightens and whitens it: hence the uſe of Iron filings in the compoſitions for fire-works, called white fire.

Strongly heated, it appears covered on the ſurface with a ſoft vitreous matter like varniſh. In this ſtate, pieces of it cohere, and, on being hammered together, weld or unite, without diſcovering a juncture. As Iron is the only metal, which exhibits this appearance in the fire, it is likewiſe the only one capable of being welded. Theſe operations, which prevent the ſuperficial ſcorification, deprive it of this valuable property; which may be reſtored again by ſuffering the Iron to reſume its vitreous aſpect, and, in ſome meaſure, by the interpoſition of foreign vitreſcible matters; whilſt none of the other metals will in any degree unite even with its own ſcoria.

Iron expands the leaſt of the metals by heat. In the act of fuſion, inſtead of continuing to expand, like the other metals, it ſhrinks; and thus becomes ſo much more denſe, as to throw up ſuch part as is unmelted, to the ſurface; whilſt pieces of Gold, Silver, Copper, Lead, Tin, put in the reſpective metals in fuſion, ſink freely to the bottom. In its return to a conſiſtent ſtate, inſtead of ſhrinking, like the other metals, it expands; ſenſibly riſing in the veſſel and aſſuming a convex ſurface, whilſt the others ſubſide and appear concave. This property of Iron, firſt taken notice of by Mr. Reaumur, excellently fits it for receiving impreſſions from moulds. By the increaſe of bulk, which the fluid metal acquires in its congelation, it is forced into the minuteſt cavities, ſo as to take the figure far more perfectly than the other metals which ſhrink. The workmen have often obſerved, that Iron, though poured quite thick into the mould, has nevertheleſs received its impreſſion in perfection; and have wondered to ſee figures of caſt Iron larger than the mould, whilſt thoſe of other metals are leſs.

Iron with other metallic bodies.] Iron is diſſolved by all the metals made fluid by ſufficient heat, except Lead; on which it floats diſtinct, as oil upon water. Gold, of all metals, acts on it the moſt powerfully: though, as Cramer obſerves, if the Iron contains any portion of Sulphur, it can ſcarcely be made to unite at all with Gold.

Among the ſemi-metallic bodies, it is averſe to any union with Mercury. No method has hitherto been diſcovered of amalgamating Iron, though Quickſilver, in certain circumſtances, ſeems, in ſome ſmall degree, to act upon it. A plate of tough Iron, kept immerſed in Mercury for ſome days, becomes brittle: and I have often obſerved Mercury adhere to and coat the ends of iron peſtles uſed in triturating certain amalgams with ſaline liquors.

Next to Mercury Zinc is the moſt difficultly combined with it; not from any natural indiſpoſition to unite, but from the Zinc being difficultly made to ſuſtain the due degree of heat. The mixture is hard, ſomewhat malleable, of a white colour approaching to that of Silver. Regulus of Antimony, as ſoon as it melts, begins to act on Iron, and diſſolves a conſiderable quantity. If the Regulus be ſtirred in fuſion with an iron rod, it will melt off a part of the Iron. Arſenic likewiſe mingles eaſily with Iron, and diſcovers a great attraction to it, forſaking all the other metals to unite with this. It renders the Iron white, very hard, and brittle.

IRON.

Vitrification.

heat procurable in the furnace of a chemiſt, and which, if brought into fuſion by additions, yields an opake black glaſs. Glaſs made from Iron, by whatever means, is always black, unleſs the quantity of vitreous matter mixed with it, be very large (h). The calces made by acids and by fire, are of various ſhades of yellow, brown, and red.

Expoſed to a burning-glaſs.

Iron placed in the focus of Tſchirnhaus's large burning-glaſs, melts in an inſtant, and looks like a black Bitumen or Pitch. The French academicians concluded from hence, that the inflammable principle of Iron was an actual bituminous matter: but no experiment gives any juſt foundation for this conjecture. The pretended Bitumen is no other than vitrified Iron; and Iron calcined or vitrified, that is, deprived of its own phlogiſton, is revived into Iron again by any vegetable or animal coal, in the ſame manner as the other metals.

Solubility in different liquors.

Iron diſſolves eaſily in all acids; it is likewiſe ſenſibly acted upon by alcaline and neutral liquors, and corroded even by thoſe which have no perceptible ſaline impregnation. Strongly heated, and quenched in water, it communicates a manifeſt taſte to the liquor. The filings expoſed to the air, and occaſionally moiſtened with water, ſoon change into ruſt. Even the oils, with which Iron utenſils are often rubbed to prevent their ruſting, in ſome meaſure contribute to promote that effect. Some employ, with better ſucceſs, oil that has been gently boiled for a time; cautiouſly pouring into the oil, towards the end of the boiling, ſome melted Lead. The oil is by this means freed from its watery phlegm, and from its acid principle, which are the cauſe of its promoting the corroſion of the metal. Animal fats are ſaid to anſwer ſtill better; theſe being void of the leaſt degree of acidity. Homberg's ſalve for preſerving Iron from ruſt, communicated to the French academy, conſiſts of two pounds of hog's Lard, an ounce of Camphor, and as much black Lead as will render the mixture of an iron colour. The Iron is to be heated, before it is anointed with this compoſition *(i)*.

(h) *Iron with vitreous matters.*] The colours which Iron imparts to Glaſs in fuſion, are various and inconſtant. Vitrified without addition, by the concentrated ſolar heat, it is ſaid to be bluiſh or purpliſh. Scorified in our furnaces, it appears of a black or dark brown, and communicates the ſame duſky hue to three or four times its quantity of colourleſs Glaſs. Its ſeveral calces, fuſed with much larger proportions of vitreous matters, impart different ſhades of yellow, reddiſh, green and blue. Practical writers in general ſpeak of one preparation giving one colour; and another, others. From ſuch experiments as I have made in this view, the colour ſeems to be influenced more by the degree and continuance of the fire, and other circumſtances in the proceſs, than by the particular manner in which the Iron is prepared. With the officinal flowers of Steel I have made a yellow and a greeniſh Glaſs; with the matter which remains after the ſublimation of the flowers, a yellow, a green, and a blue; without being able to determine the particular circumſtances in which either of theſe colours might with certainty be produced. One of the bluiſh green glaſſes, on being melted a ſecond time, loſt its bluiſh caſt, and became of a deeper green than at firſt. After a third fuſion it looked green, yellow and red in different parts of the maſs. With the calx made by long reverberation, I obtained a red but an ill-coloured Glaſs; not the lovely one which Kunckel promiſes. A piece of this Glaſs kept long in fuſion, diſcovered a tendency to blueneſs.

Preſervation from ruſt.

The vitriolic acid requires to be diluted with three or four times its quantity of water, to enable it effectually to diſſolve Iron. During the diſſolution, a ſtrong ſulphureous vapour ariſes, which, on the approach of a candle, takes fire *(k)*. The ſolution is of a graſs green colour. On ſtanding, it gradually depoſites great part of the Iron in form of a yellow or reddiſh calx or ochre. Duly evaporated, it ſhoots into rhomboidal cryſtals, which are the green Vitriol, or

Solution in vitriolic acid, inflammable vapour:

(i) *Preſerved from ruſt.*] Mr. Reaumur has diſcovered a compoſition which appears ſuperior to all the foregoing. Expreſſed Oils, expoſed to the air in flat ſhallow veſſels ſo as juſt to cover the bottom, become thick, without loſing their tranſparency, or acquiring any brown or other colour, which they always do when thickened by boiling. The inſpiſſated Oil, ſkilfully mixed with a ſolution of Copal in Spirit of Wine, forms an elegant hard varniſh. Poliſhed Iron, made a little hotter than the hand can bear, and rubbed with a ſtick of this varniſh, appears, as ſoon as cold, covered with a ſolid, thin, tranſparent coat, without the leaſt injury to its colour or appearance.

(k) *Inflammable vapour.*] This vapour is permanent and elaſtic, and ſeems to have a great analogy to the inflammable damps in mines. It may be collected and preſerved in bladders; which being applied to the mouth of the veſſel, wherein the diſſolution is made, will ſoon be filled and diſtended by it. After keeping for ſeveral weeks, a little of the vapour, forced out near a candle, inſtantly took flame as at firſt, IRON. or ſalt of Steel, of the ſhops. — The calx precipitated from this ſolution by fixed alcaline ſalts, is exceeding difficultly reducible into its metallic ſtate.

In the nitrous acid; The nitrous acid undiluted, acts violently on Iron, corrodes it plentifully, but diſſolves little; and what has thus once been corroded, will not diſſolve in freſh acid. If the acid has been diluted at firſt with water, it takes up a conſiderable proportion, provided the metal be leiſurely added. If the ſolution is performed with extreme ſlowneſs, the colour will be green; if otherwiſe, of a dark red. It does not cryſtallize; and if inſpiſſated to dryneſs, deliquiates in the air.

In the marine acid, The marine acid acts leſs vehemently on Iron than the nitrous, and does not diſſolve ſo much. The ſolution is of a ſaffron or gold yellow colour: it does not cryſtallize; and, if inſpiſſated, leaves a greeniſh ſaline maſs, which diſſolves not only in water but likewiſe in Spirit of Wine, and runs in the air into volatilized. a yellow liquor. In diſtillation, a conſiderable portion of the Iron is volatilized (*l*). Ammoniacal Salts likewiſe, compoſed of the marine acid and volatile alcalies, elevate ſo much of this metal in ſublimation, as to receive from it a deep orange colour. This preparation is kept in the ſhops under the name of *flores martiales*, *Sal ammoniacum martiale*, or *mars diaphoreticus*. It is commonly made from one part of clean filings of Iron, and two of Sal Ammoniac, well mixed together, and ſublimed. A little urinous ſpirit

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(*l*) *Iron volatilized by Spirit of Salt.*] The ſpirit which diſtils towards the end of the proceſs appears yellow. This is followed by a yellowiſh or deep reddiſh Sublimate, which gliſtens like the ſcales of fiſhes; leaving behind a ſubſtance which conſiſts of thin gloſſy plates like Talc.

Iron with other metallic ſolutions.] Iron precipitates from acids all metallic ſubſtances except Zinc, and the newly diſcovered ſemimetals Regulus of Cobalt and Nickel. — By ſolutions of Copper in acids, the Iron is ſtained of a copper colour; the Copper being extricated from its menſtruum in its metallic form, and adhering to the ſurface of the Iron. By ſolutions of Gold combined with rectified Spirit of Wine, it is in like manner covered with a golden coat. The preparation of Gold, ſaid to anſwer beſt for this purpoſe, is a Tincture drawn from a mixture of Gold-leaf, Sea-ſalt, and Alum, melted together, or boiled in water to dryneſs.

ſpirit ariſes before the yellow flowers, and generally a little marine acid after them. The reſiduum, ſet in a cellar, runs into a liquor ſimilar to that made with Spirit of Salt directly; called *liquor martialis*, or *liquamen martis*.

With vegetable acids.

Solution in alcalies.

Vegetable acids, even wines that are but ſlightly acidulous, diſſolve a conſiderable quantity of Iron into a reddiſh liquor. The purer acids, as diſtilled Vinegar, by proper management, cryſtallize with it. —— Fixt alcaline Lixivia ſeem to have little effect upon Iron in its metallic ſtate: but if a ſolution of Iron, made in the nitrous acid, be dropt into a ſaturated lixivium, the Iron remains permanently diſſolved in the alcali. The liquor appears at firſt of a yellowiſh red colour; when loaded with the Iron, of a deep blood-red. Here the acid ſerves only as a medium of union betwixt the Iron and the Alcali, and after the union is once effected, has no ſhare in the continuance of it; the acid forming, with a part of the alcaline Salt, a true Nitre, which may be ſeparated from the martial ſolution by cryſtallization. — Much has been ſaid in books, of preparations of Iron that fulminate in the fire: I have made numerous trials for obtaining the *Mars fulminans*, without being ever able to ſucceed.

Uſes in ſtaining and dying.

Solutions of Iron made in acids give a yellow ſtain to linen, &c. and ſtrike a black colour with galls and other vegetable aſtringents (*m*). Theſe are very

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(*m*) *Black with vegetable aſtringents.*] This property of Iron affords a commodious method of diſtinguiſhing minute portions of it in mineral waters or other liquors. A ſingle grain of Vitriol of Iron, diſſolved in a gallon of water, inſtantly diſcovers itſelf, on adding a little powdered Galls, by a duſky blue colour. A more ſaturated ſolution of the Vitriol ſtrikes with Galls a deep black colour; and this black mixture, diluted, appears blue like the former. If the liquor is impregnated with a minute portion of alcaline Salt, fixed or volatile, inſtead of a blue or blackiſh, a purpliſh red tincture is produced. This is the colour which Chalybeate mineral waters ſtrike with Galls.

As it is only with vegetable aſtringents that Chalybeate ſolutions ſtrike a blue or a black colour; theſe liquors have been employed as a teſt of aſtringency in vegetable ſubſtances. I have obſerved, however, that ſome vegetables, manifeſtly and powerfully aſtringent, do not exhibit this phœnomenon; their aſtringency reſiding in a principle not diſſoluble very valuable properties of Iron to the callico-printer, the ſtainer of leather, wood, *&c.* and the dyer. For linen and leather, the metal is commonly diſſolved in ſour whey or ſmall-beer; for dying, the Vitriol is made uſe of, (ſee Vitriol). Pigments. This metal affords alſo, in its calces, red and yellow pigments to the painter; and a fine blue in the preparation, called, from the place where it was firſt diſcovered, Berlin or Pruſſian blue. —— (*n*) A ſlight ſolution of Vitriol has been

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diſſoluble in watery liquors, and not miſcible with the vitriolic ſolution. The reſinous aſtringent, Peruvian bark, mixed with ſolution of Vitriol, in ſmall or in large proportions, in the form of powder, infuſion, decoction, extract, vinous or ſpiritous tincture, gives not a blue or a black, but a green colour, which with certain proportions is very deep and bright.

(*n*) *Pruſſian blue.*] Pruſſian blue is prepared by precipitating a ſolution of green vitriol and Alum with a Lixivium drawn from fixt alcaline Salt that has been calcined with animal coals. Commonly about three parts of Alcali and two of dried ox blood are calcined ſo long as any flame appears, then thrown into boiling water, and the ſtrained decoction poured into a hot mixture of ſolutions of four parts of Alum and one or leſs of Vitriol. The liquor inſtantly becomes thick or curdly, and looks at firſt of a greyiſh colour, which changes to a brown, and in a little time to a bluiſh green. The matter being well ſtirred together, and mixed with a quantity of hard ſpring-water, a green precipitate ſubſides. Spirit of Salt poured upon the edulcorated powder, diſſolves a part, and leaves the reſt blue.

Mr. Geoffroy is the firſt who has given any plauſible theory of this proceſs, or any rational means for improving it. He obſerves, that the Pruſſian blue is no other than the Iron of the Vitriol, revived by the inflammable matter of the alcaline Lixivium, and perhaps brightened by an admixture of the white earth of the Alum; that the green colour proceeds from a part of the yellow ferrugineous calx or ochre unrevived, mixing with the blue; and that the Spirit of Salt diſſolves this ochre more readily than the blue part, though it will diſſolve that alſo by long ſtanding, or if uſed in too large quantity. From theſe principles he was led to increaſe the quantity of inflammable matter, that there might be enough to revive the whole of the ferrugineous ochre, and produce a blue colour at once without the uſe of the acid ſpirit. In this he perfectly ſucceeded, and found, at the ſame time, that the colour might be rendered of any degree of deepneſs or lightneſs at pleaſure. If the Alcali is calcined with twice its weight of dried blood, and the Lixivium, obtained from it, poured into a ſolution of one part of Vitriol to ſix of Alum, the liquor acquires a very pale blue colour, and depoſites as pale a precipitate. On adding more and more of a freſh ſolution of Vitriol, the colour becomes deeper and deeper, almoſt to blackneſs. He imagines, with great probability, that the blue Pigment thus prepared will prove more durable in the air, mingle more perfectly with other colours, and be leſs apt to injure the luſtre of ſuch as are mixed with or applied in its neighbourhood, than that made in the common manner; the tarniſh and other inconveniencies,

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been employed by ſome as an aſſay liquor for diſtinguiſhing French brandies from common ſpirits prepared in imitation of them; French brandy having uſually an aſtringent impregnation from the oaken caſks in which it has been kept, and hence ſtriking a bluiſh or black colour with the Chalybeate ſolution; whilſt ſpirits, tinctured only with melaſſes, burnt ſugar, &c. give no ſuch colour. The principle, on which the blue colour depends, ſhews that it is no certain teſt. All ſpirits will exhibit it if impregnated with aſtringents; and French brandies will not, without ſuch impregnation.

Treated with Nitre, and Sulphur.

Iron deflagrates with Nitre, and renders the Salt alcaline and cauſtic (*o*). It readily unites with Sulphur;

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to which common Pruſſian blue is ſubject, ſeeming to proceed from the acid ſpirit, which cannot be totally ſeparated by any ablution. —— He takes notice alſo of an amuſing phœnomenon, which happens upon mixture. When the liquors are well ſtirred together, and the circular motion as ſoon as poſſible ſtopped, ſome drops of ſolution of Vitriol (depurated by long ſettling) let fall on different parts of the ſurface, divide, ſpread, form curious repreſentations of flowers, trees, ſhrubs, flying inſects, &c. in great regularity and perfection. Theſe continue ten or twelve minutes: and on ſtirring the liquor again, and dropping in ſome more of the ſolution of Vitriol, are ſucceeded by a new picture.

Mr. Macquer has ingeniouſly applied the preparation of this pigment to the dying of wool and ſilk; and found means of fixing the blue fecula in their pores. By dipping cloth firſt in a diluted ſolution of Vitriol and Alum, then in the ley diluted, and afterwards in water acidulated with Spirit of Vitriol, it acquires a light blue colour; which becomes deeper on repeating the dippings alternately in the ſame order as before; and adding to the liquors each time a little more of the reſpective ſaline matters. This blue dye, he ſays, in beauty and luſtre exceeds that of Indigo and Woad as far as ſcarlet does the Madder red; and penetrates the whole ſubſtance of fulled cloth, without weakening it. The colour is durable in the air, and ſtands boiling with Alum water, but is diſcharged by Sope, and, without certain precautions, liable to be ſpecky or unequal. See the Memoirs of the French academy for the year 1749.

(*o*) *Iron with Nitre.*] A part of the Iron is thus rendered ſoluble in water along with the alcalized Salt. A mixture of equal parts of Iron filings and Nitre, injected into a ſtrongly heated crucible, and after the detonation thrown into water, tinges the liquor of a violet or a purpliſh blue colour. This ſolution however is not permanent. Though the liquor at firſt paſſes through a filter without any ſeparation of the Iron, yet on ſtanding for a few hours, the metal falls to the bottom in form of a brick-coloured powder. It is pretty ſingular, that volatile alcalies inſtantly precipitate the Iron from this fixed alcaline ſolution.

IRON.

Artificial earthquakes.

phur; and when combined with it, like the other refractory metals, proves much eaſier of fuſion than by itſelf. A mixture of Sulphur and Iron filings, moiſtened with water and preſſed down cloſe, in a few hours ſwells and grows hot, and, if the quantity is large, burſts into a flame. From this phœnomenon the chemiſts have endeavoured to account for earthquakes, ſubterraneous fires, and hot mineral ſprings.

Medical hiſtory of Iron.

Iron is mechanically the moſt uſeful, and medicinally the moſt ſalutary, of all metals; poſſeſſing no deleterious power like moſt of the others, though its imprudent uſe may nevertheleſs be productive of dangerous conſequences. Its primary operation is, to conſtringe and corroborate: and hence in cachexies and chloroſes, in debilities and relaxations of the ſolids, it proves a medicine of great efficacy; whilſt in the oppoſite circumſtances it is as injurious as in theſe it is beneficial. Though it always acts immediately by an aſtringent quality, it often proves, in its conſequential effects, aperient; promoting natural evacuations where the obſtruction depends upon a laxity of the veſſels; as well as reſtraining immoderate ones ariſing from the ſame cauſe. — A great variety of preparations of it have been employed for medicinal uſe; as ſolutions in different acids, both mineral and vegetable, by themſelves or in conjunction with vinous ſpirits, in their liquid ſtate, or inſpiſſated or cryſtallized; calces or croci made by fire alone, or by precipitation from acids, or by urging the inſpiſſated or cryſtallized ſolutions with a ſtrong fire till the acid has been expelled; and the ruſt made by expoſing the filings to the air. The crude filings, are often as effectual as any of the preparations: if procured from the workmen in Iron, they ſhould be carefully cleanſed by winnowing and waſhing. For obtaining the ruſt moſt expeditiouſly, the filings ſhould be ſpread thin, moiſtened, and ſet in a moderate warmth. Mr. Bourdelin obſerves, that the Iron increaſes in weight in this proceſs, and that when thoroughly ruſted, ſo as to imbibe no more water, it yields in diſtillation a volatile urinous ſpirit. Iron combined with acids, proves more aſtringent than by itſelf; but when the acid is ſeparated, and the metal reduced to a calx, its activity is greatly diminiſhed. The combination with vitriolic acid, or *Sal martis*, is directed to be made in the ſhops, by diſſolving Iron filings in the acid, and cryſtallizing the ſolution. This however is a needleſs labour, the common green vitriol, duly purified, being one and the ſame thing. If the Vitriol is ſuſpected of containing any Copper, a little freſh Iron added to the ſolution of it, will effectually precipitate all remains of that metal. Even a pure Vitriol of Copper may be converted into a pure Vitriol of Iron, by diſſolving it in water, and adding Iron to the ſolution; the Iron throwing down the Copper, and being diſſolved in its place. The vitriolic and vegetable acids are the only ones with which Iron cryſtallizes or preſerves a ſolid form. The marine renders it moſt effectually ſoluble in Spirit of Wine.

IRON.

Natural Hiſtory.

Iron is exceeding rarely, if ever, found native in the earth. I have never yet ſeen a ſpecimen of pure native Iron; the maſſes which have been ſhewn me as ſuch, being either not attracted by the Magnet, or not diſſoluble in Aqua fortis. Its ores on the other hand are extremely plentiful in almoſt all parts of Europe. But South America, ſo rich in Gold and Silver, has little of this moſt uſeful metal. The richeſt ores of Iron are compact and ponderous, of a browniſh, reddiſh brown, or red colour (*p*): they ſcarcely ever participate

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(*p*) *Iron ores.*] Some of the Iron ores, in colour and appearance, do not ill reſemble Iron itſelf; as the grey ore of Derbyſhire, and the bluiſh of the foreſt of Dean in Glouceſterſhire: moſt of the Swediſh ores are likewiſe of this kind. Others are blackiſh, brown, red, yellowiſh, or ruſty coloured: theſe are the moſt common ſorts in England and in Germany. There is one very ſingular ſpecies, of a ſtriated texture, a pale yellowiſh or greyiſh colour, oftentimes white, and in ſome degree pellucid: this, though in its crude ſtate it promiſes nothing metallic, on being moderately calcined, diſcovers, by the deep colour it aſſumes, that it abounds with Iron. Cramer informs us, that it gives out, on fuſion, from thirty to ſixty pounds of excellent Iron upon the hundred. Some of the richer ores yield no leſs than eighty on the hundred.——Different

IRON.

cipate of perfect Sulphur (the Pyritæ excepted) and contain but little foreign matter: ſuch are, the Magnet, the Hæmatites or Blood-ſtone, the common Iron ſtone, and Ruddle. The running down of the Iron-ſtone requires no particular management, a ſtrong charcoal fire being the principal point: the ore is thrown in among the burning fuel, with the addition ſometimes of Quick-lime or Limeſtone (*q*).

Beſides

Different kinds of Iron-ſtone are, in ſome mines, found adhering to the tops of caverns, in form of icicles or ſtriæ, ſometimes irregularly cluſtered together, ſometimes hanging down like the briſtles of a bruſh: whence the name Bruſh-iron-ore. Other particular forms of the Iron-ſtone have occaſioned a variety of fanciful names to be met with in ſome of the metallurgic writers.

(*q*) *Smelting of Iron ores.*] The ores of Iron are commonly calcined previous to the fuſion; the harder ones, though they ſhould contain nothing ſulphureous or arſenical, requiring that proceſs to render them pulverable. In the large works, a quantity of the ore is placed on a bottom of wood or charcoal, intermingled with ſtrata of the ſame kind of fuel; the pile carried up to a conſiderable height, and ſet on fire.

The fuſion is performed in furnaces twenty or thirty feet high, and eight or ten feet wide in the middle, but narrower above and below. The furnace is charged at top with charcoal, and the fire excited by large bellows moved by water. When the whole internal furnace appears of a ſtrong white heat, the ore is thrown in, by little at a time, with more charcoal over it, and commonly a portion of Lime-ſtone, the true uſe of which is probably, not as has been generally ſuppoſed, to abſorb Sulphur, but to promote the fuſion (ſee page 18.) The ore, gradually melting, drops down through the fuel into the receiver or bottom of the furnace, where a paſſage is open for taking off the ſcum or droſs. The metal, now in ſtrong fuſion, is let out, by a tap-hole, into furrows made in a bed of ſand: the large maſs, which ſets in the main furrow, is called by the workmen a *ſow*, and the leſſer ones *pigs*, of Iron. Chimney-backs, ſtoves, garden-rollers, &c. are formed of this rough metal taken out of the receivers with ladles, and caſt into moulds made of fine ſand. Two or three tons of Iron are run off in twenty-four hours: before the force of water was called in aid to work the bellows, ſcarce an hundred weight could be obtained in a day, and a large quantity of the metal was left in the droſs: hence, in ſome places, the ſlags of the old works are now re-melted to advantage along with freſh ore. From the richneſs of the ſlags of different ores left by former times, ſome have been miſled into an opinion, that the metal was regenerated in them.

From the great conſumption of wood in this buſineſs, and its ſcarcity in ſome places where there are rich mines of Iron, attempts have been made to ſubſtitute other fuels. Peat has been found to anſwer tolerably well: in ſome parts of England a quantity of this has, for a conſiderable time, been mixed with the charcoal; and a patent has been lately obtained for running down the ore with peat alone. Pitcoal renders the Iron hard and brittle: this incovenience is ſaid to be in good mea-

ſure

Beſides the minerals which are commonly worked for Iron, there are many others, in which ſmaller quantities are contained: from this metal the coloured clays and boles, and even the precious ſtones, receive their colour. Iron is truly an univerſal metal: ſome portion of it has been diſcovered in all the mineral earths or ſtones that have been examined, in the ores of all other metals, and even in the aſhes of vegetables and animals. It was long diſputed betwixt two of the French academicians, Lemery and the elder Geoffroy, whether the Iron, diſcovered by the magnet in vegetable-aſhes, pre-exiſted in the plant, or was produced in the burning. Mr. Geoffroy's opinion is evidently the true one, namely, that the ferrugineous earth or calx exiſts in the vegetable, and is reduced into perfect Iron by ſome of the inflammable matter of the ſubject combined with it in the fire. The mineral earths and ſtones impregnated with Iron, and even its richeſt ores, contain no other than this calx of Iron; and no art can extract from them a grain of metal, without the introduction of inflammable matter.

Contained in coloured earths and ſtones,

in animals and vegetables.

Iron proves greatly different in hardneſs, brittleneſs, malleability, *&c.* according to the quality of the ore it is obtained from, (*r*) and the operation it has

Differences in its quality.

ſure prevented, by previouſly coaking the coal, as is cuſtomary to fit it for the drying of malt.

The impure Iron, as run from the ore, is melted down in another furnace, intermixt with charcoal; a ſtrong blaſt of air being impelled on the ſurface of the metal, by which its fuſion is remarkably promoted. On diſcontinuing the action of the bellows, the Iron thickens into a maſs called a *loop*, which is conveyed under a large hammer raiſed by the motion of a water-wheel. The Iron, beat into a thick ſquare, is heated till ready to melt, and forged again: by a few repetitions of this proceſs, it becomes completely malleable, and is at length formed into bars for ſale. A large quantity of vitreous ſcoria ſeparates both in the fuſion and the forging: the rough caſt Iron, obtained from ſome ores, loſes more than half its weight in being made into bars.

(*r*) *Differences according to the quality of the ore.*] There are very remarkable differences in the Iron obtained from different ores: from what particular admixtures or other cauſes they proceed, has hitherto been too little examined. The Iron run from ſome of the German ores, when forged only to a certain point, is found to be a good Steel; whilſt that of many others, taken in the ſame intermediate ſtate betwixt caſt and completely forged Iron, cannot be worked either as Steel

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has undergone. As firſt run from the ore, it contains an admixture of crude earth not perfectly reduced to a metallic form, and hence proves hard and brittle: (s) by repeated forgings this earth is forced out from

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Steel or Iron. The Swediſh, and ſome of our own ores, yield an excellent tough Iron; whilſt others give a brittle metal, that cannot, by any forging, be made perfectly malleable, and hence employed only for ſome kinds of nails and heavy works. The inferior ores are ſaid to be meliorated by mixing two or three different ſorts together.

(s) *Caſt Iron.*] Pure caſt Iron is, for the moſt part, ſo hard, as not to yield in the leaſt to the file or the chiſſel; and extremely brittle, both when cold and when ignited: caſt into thin plates it cracks, on being haſtily cooled, like glaſs. Broke, it appears of a dull white colour, approaching to that of unpoliſhed Silver; and of a ſmooth and uniform texture, compoſed of plates laid ſo cloſe together as ſcarce to be diſtinguiſhed even by a microſcope.—The more impure ſorts are leſs hard to the file, but not leſs brittle under the hammer; their colour is much darker, ſometimes a duſky grey, ſometimes almoſt black; their texture often granulated. On melting them, a quantity of glaſſy ſcoria ariſes to the ſurface; which taken off, leaves the the metal pure and white, like the foregoing ſort.

Pure caſt Iron, ſurrounded with animal aſhes, and expoſed to a fire not ſufficient to melt it, becomes, in a ſhorter or longer time, according to the ſtrength of the fire and the thickneſs of the metal, ſo ſoft, that ornaments or utenſils made of it, however hard before, may now be eaſily cut, filed, embelliſhed, or freed from their ſuperfluities. The gradual changes produced in this proceſs are pretty remarkable.

Iron, ſuffered to cool in the mould, appears on the ſurface of a ſlate blue colour; a ſure mark of its being hard. After the cementation has been continued for a certain time, it looks externally of a dark, coffee, or blackiſh colour, internally far leſs white than before, and no longer of a ſmooth, but of a rough granulated, ſtructure. In this ſtate it yields to the file, if ſlowly cooled; but if cooled haſtily by quenching in water, or if heated a ſecond time and then quenched, it is not touched by the tool: hence works of caſt Iron, ſoftened to this degree, may be filed or cut, and afterwards readily hardened again. It does not bear the hammer when cold, but proves in ſome meaſure malleable when ignited: when ſtrongly heated, I have generally found it crack or fly in pieces from a moderate blow.

On further continuing the cementation, the dark colour, which the metal had before acquired, gradually goes off, and at length changes into a white, with a conſiderable degree of brightneſs, which the Iron had nothing of at firſt: the texture likewiſe alters, but not equally in all kinds of Iron, ſome proving granulated and others plated. The metal is now fully ſoftened; it may be eaſily cut with a chiſſel, bent without breaking, and extended under the hammer; nor does it acquire any conſiderable hardneſs on being heated and quenched in cold liquors.

In proportion as the Iron becomes ſoft, it loſes its fuſibility. If the cementation is continued only till the outſide is ſoftened, on raiſing the fire, all the inner hard core will melt and run out, leaving the outer ſoft part entire, and of its original form. If any part of the ſurface is covered from its pores, and the metal becomes ſofter and more malleable (*t*). The workmen commonly judge of the goodneſs of caſt Iron, from its bearing a ſtrong fire, when made into veſſels, without bliſtering; and of that of forged Iron, from its being malleable both when hot and cold, making good Steel, and laſting well when employed for ſuch uſes as require it to be kept wet, as in pegs for the axle-trees of mill-wheels, *&c.*

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covered with ſand, or left uncovered with the ſoftening matter, the melted core will run out there.

Sand and powdered Flint ſomewhat retard the ſoftening. Argillaceous and gypſeous earths, particularly the latter, occaſion the Iron to ſcale greatly. The mineral calcareous earths have nearly the ſame effect as animal aſhes, but with leſs certainty: after the Iron has been ſoftened by them in a moderate fire, it ſometimes, in a ſtronger, reſumes its original hardneſs: they are likewiſe apt to make the ſurface ſcale, and thus obliterate the finer impreſſions received from the mould. Bone-aſh itſelf is ſubject alſo to this laſt inconvenience, where the largeneſs of the maſs of metal requires the fire to be long continued: the admixture of a little powdered charcoal prevents the ſcaling, without ſeeming to affect the ſoftneſs or hardneſs.

The foregoing obſervations are drawn chiefly from the experiments of M. Reaumur, referred to by our author. I have added not a few of my own, but without being able to add much to the conſequences deducible from his; or to diſcover the principle on which the change is effected; or to ſoften the pureſt and fineſt caſt Iron near ſo effectually by cementation as by forging.

(*t*) *Forged iron.*] When caſt Iron is heated till ready to melt, and compreſſed by repeated blows of large hammers, a quantity of vitreous matter is forced out and thrown off; its parts are more regularly arranged; the plates rendered ſmaller and more diſtinct, by degrees changed into grains, and at length into fibres. Fine plates regularly arranged, ſmall grains, or fibres like thoſe which appear upon the fracture of wood, are marks of tough Iron, provided it is not ſulphurated: large and irregular plated Irons are univerſally ſhort or brittle. The colour of the fracture is uſually whitiſh, and conſiderably bright; though ſome, even of the better ſorts of Iron, look dull, without any brightneſs.

Pure well forged Iron is malleable both when cold and hot, though not with equal facility: the further it is heated, it extends the more eaſily, and is leſs liable to crack.——Some ſorts of Iron, though malleable when cold, prove entirely brittle if heated red; others are brittle when cold, and malleable only whilſt ignited: the former are called by the workmen *red-ſhare*, the latter *cold-ſhare*, Irons. The imperfection of the firſt is ſuppoſed to be owing to an admixture of Sulphur; that of the ſecond proceeds wholly from a want of ſufficient forging.—Forged Iron is a little heavier than the caſt; in the proportion of about $7\frac{8}{10}$ to $7\frac{1}{10}$. It ſcorifies much more in the fire, and does not melt without additions or the immediate contact of the fuel.

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Steel.

Forged Iron is converted into Steel, by cementation, in cloſe veſſels, with inflammable and ſaline ſubſtances, as the horns and hoofs of animals, or mixtures of Sea-ſalt, ſoot, and wood aſhes. Steel is much harder, more brittle, and more elaſtic than the Iron was at firſt; and all theſe qualities are, in good meaſure, at the command of the artiſt. Heated a little, and quenched in water, it proves extremely hard: by an increaſe of the heat, it becomes ſofter and ſofter; and by a continuance or repetitions of it, returns into Iron again; loſing by degrees the inflammable or other principles, the introduction of which had made it Steel (u). The hard caſt Iron, as

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The author above mentioned obſerves, that the ſubſtances which ſoften caſt Iron by cementation, increaſe the ſoftneſs of the forged to a certain point; that if the operation is continued beyond this period, they render it harder and more brittle than at firſt; that gypſum remarkably promoted the fuſion of the metal; bars of Iron, ſurrounded with gypſum, having ſcaled in a moderate heat, and, in no very ſtrong one, melted. It is commonly ſuppoſed that Iron, by whatever means it is brought into fuſion, totally loſes its malleability: but I have found that when thus melted with gypſum, it remains malleable in a great degree; and that it will now melt a ſecond time, without any addition, and ſtill retain its malleability. The Iron, ſurrounded with the gypſum, did not perfectly melt till the fire had been raiſed ſo high that the gypſum begun to diſſolve the Heſſian crucibles, which were ſometimes corroded internally to the thinneſs of paper, and ſometimes perforated.

Forged Iron, cemented in cloſe veſſels with vegetable or animal coals, gains a ſenſible increaſe both in bulk and weight, and now commences Steel. —— From the remarkable changes produced in Iron by earthy and inflammable matters, I was led to ſubmit Copper, and ſome other metals, to the ſame treatments, but could not obſerve that they ſuffered any change.

(u) *Steel.*] Steel is found to differ in quality according to the particular ingredients with which the cementation is performed, as well as the goodneſs of the Iron it is made from. M. de Reaumur obſerves, that inflammable ſubſtances alone, as ſoot, charcoal, animal matters, render the Steel hard to work, and apt to crack; that the admixture of abſorbent earths, as wood aſhes, prevents this inconvenience; that a little Sea-ſalt, added to theſe, contributes to the fineneſs and durability of the Steel, and at the ſame Time expedites the change; whilſt ſome other ſaline ſubſtances, as Sal Ammoniac, Sandiver, Vitriol, alcalized Nitre, rendered it far leſs durable. The cementation has been uſually performed in earthen coffins or cheſts, fitted with covers, of ſufficient capacity to receive a great number of bars at once. There is a large Steel-work in Yorkſhire, where the furnace itſelf is divided into partitions or chambers for receiving the Iron with the cementing mixture, with ſpaces between for the paſſage of the fire: the fire is raiſed by degrees for a week, and then ſuffered to decay of itſelf. The increaſe which the

Iron

as well as Steel, is rendered ſoft, by cementation with earthy matters, as bone aſhes, mixed with a little powdered charcoal. See Reaumur's treatiſe on the converſion of forged Iron into Steel, and the ſoftening of caſt Iron.

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Iron gains in this proceſs is ſaid to be ſo conſiderable as to bear the charges of the fuel.——The caſe-hardening of Iron, by cementing it for a little time with burnt horns, leather, and other like ſubſtances, is no other than a ſuperficial converſion of it into Steel.

Steel, ſuffered to cool leiſurely in the furnace, yields to the file; breaks, whilſt cold, from a moderate blow; and diſcovers a laminated texture and dull colour, though the Iron was fibrous and bright before. Conſiderably heated, it may be hammered or welded; and if ſuddenly cooled, by quenching in cold liquors, proves much harder than at firſt, of a bright whitiſh ſurface, and no longer of a plated, but of a granulated ſtructure: the grains are larger or ſmaller according as the Steel is more or leſs hard. Both the texture and colour are always different from thoſe of the Iron which it was made from; though ſome kinds of Iron are, in theſe reſpects, little different from ſome kinds of Steel.

A bar of white poliſhed Steel, laid upon burning charcoal, ſo as to heat ſlowly, becomes at firſt paler; then of a dilute yellow, which deepens by degrees into a gold colour: as the heat increaſes, the gold changes to a purple; this is ſucceeded by a violet, and the violet by a deep blue, which weakens inſenſibly to a water colour, the laſt ſhade that can be diſtinguiſhed before the bar grows red-hot. All theſe colours may be exhibited on the ſame bar at once, by applying the heat only at one end; and fixed or detained upon it, by quenching it in cold water as ſoon as they appear.

Theſe different colours are accompanied with manifeſt differences in the texture, hardneſs, and tenacity of the Steel, and prove ſure guides to the workman for giving his ſprings and tools the temper proper for each. Steel, in its white ſtate, is exceſſively hard, not to be filed, ſcratched, or cut, and incapable of receiving any impreſſion or alteration of form without extreme violence: hence it is fit for making dyes to ſtamp coins and medals, for forming the ſurface of anvils, hammers, &c. When yellow, it proves more tractable, yet ſufficiently hard to make files, drills, and other tools capable of cutting ſuch as is of a violet or blue colour. In this laſt ſtate, it is ſomewhat ſoft, ſo as to be punched, filed, drilled, toothed, made into ſaws; and highly elaſtic, fit for ſprings, which may be coiled or uncoiled without breaking or injury.

If Steel be cemented afreſh with the Steel-making mixture, or if the proceſs at firſt be long continued; the metal proves exceſſively brittle, incapable of being welded, apt to crack and fly in pieces in forging, and, on raiſing the fire, melts like caſt Iron. Cementation with abſorbent earths, or fire alone, change it from this ſtate firſt into tractable Steel again, and afterwards into malleable Iron, ſomewhat finer and purer than the Iron was at firſt.

Mr. Reaumur ſuppoſes, that common caſt Iron itſelf is no other than an impure ſpecies of melted Steel; and that, on ſoftening it, whether by cementation, or by forging, it becomes perfect Steel before it becomes malleable Iron. The German Steels are made directly from caſt Iron, by forging it only to a certain point. This kind of Steel is leſs certain in quality than that made

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Some of the ores of Iron are more valuable for other uſes, than for being worked as Iron ores. Such are, (x)

Different ſorts.

I. EMERY: *Smiris*, *ſmerillus*, *ſmyrites*, ſo called from σμαω or σμεω, to cleanſe or poliſh. Three ſorts of

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from forged Iron, and has generally veins of ſoft Iron. An account of the manner of preparing it was publiſhed ſome years ago in a treatiſe *Sur l'acier d'Alſace.*

The ancients have been ſuppoſed, from the hardneſs of ſome of the ſtatues which they have left us, and from the Egyptian obeliſks, which, though carved with a variety of figures, reſiſt the tools of later ages; to have had peculiar methods of making Steel of a degree of hardneſs ſufficient to cut thoſe refractory ſtones. Dr. Liſter complains, that this valuable ſecret is now loſt; and that the proceſſes, uſed by moſt nations, are a poiſoning of Iron by mineral Salts, rather than a true making of Steel. —— So far as can be judged from the imperfect accounts given by Ariſtotle and Pliny, the ancient Steel was made by keeping forged Iron for a certain time in melted caſt Iron. Agricola deſcribes a proceſs on the ſame principle, which Kircher aſſures us was practiſed in the iſland Ilva from the time of the Romans to his own. And this is the method which Liſter propoſes, for retrieving the loſt ſecret. —— The proceſs is curious, and affords, by proper management, a perfect Steel, but not ſuperior in hardneſs to the common ſort. It is probable, that the ſecret of the ancients did not conſiſt ſo much in giving their tools an extraordinary hardneſs, as in employing the ſtones in a ſofter ſtate than that in which we now find them. There are ſundry ſtones which have their hardneſs improved by long expoſure to the air. There are others which in their natural ſtate are ſo ſoft as to be eaſily cut with a knife and turned into a lathe, but gain from fire a degree of hardneſs which is proof againſt the chiſel. See page 38.

(x) *Ores valuable for other purpoſes.*] Such alſo is the *lapis hæmatites* or blood-ſtone, the *glaſs-kopf* of the German writers. This is an elegant Iron ore, generally of a reddiſh colour, very ponderous, and of great hardneſs, inſomuch as to be uſed, like Emery, for poliſhing Glaſs and Steel. Its figure is ſomewhat pyramidal: one ſide is convex, the other angular. Broke longitudinally, it exhibits ſtriæ converging to the ſmaller end. Its tranſverſe fracture reſembles that of ſoft Steel. Expoſed to a moderate fire it falls into ſcales, and in this ſtate adheres readily to the magnet, and gives out its Iron to acids; neither of which had any action on it before. In a vehement fire, it yields a white brittle Regulus of Iron, which is very difficultly rendered malleable. Nevertheleſs, in ſome parts of Germany, where it is plentiful, it is ſaid to be worked for Iron to advantage.

The native red and yellow ochres, employed as pigments by the painters, are no other than ores of Iron, compoſed of a calx of the metal blended with an argillaceous earth. The ponderous deep red ochre, called ſmit, and the reddle or red chalk, are rich in Iron. Swedenborgh informs us, that in ſome provinces of Sweden, different ochres, frequent in marſhy places and at the bottoms of ponds, are dug in ſummer when the waters have dried up, and ſmelted for Iron; that ſome yield upwards of one fifth their own weight, though there are others which ſcarce afford one twentieth.

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of this ſtone are mentioned by authors; a golden, cupreous, and ferrugineous Emery. The golden Emery is ſaid to be found in the Peruvian and other American mines, to be of a reddiſh colour, to have ſmall veins or ſpecks of Gold and Silver imbedded in it, to be very rare, and its exportation to be pro-

Manganeſe or Perigord ſtone, *Magneſia, lapis pretacorius*, the *braunſtein* of the Germans, has hitherto been ranked among the ores of Iron. This mineral is uſually of a dark grey colour; ſometimes bright and ſtriated like Antimony; ſometimes dull, with only a few ſmall ſtriæ. It is found chiefly in mines of Iron; though conſiderable quantities are likewiſe met with in the Lead mines of Mendip hills.

Manganeſe, ſtrongly calcined, becomes brown. Small proportions of the calx, melted with Borax, with compoſitions of Flint and Alcali, or with common Glaſs, communicate different ſhades of purpliſh or red colours. On continuing the Glaſs in ſtrong fuſion, the colour which it had received from the Manganeſe diſappears, and the effect of ſundry other colouring matters alſo is at the ſame time deſtroyed: hence the uſe of Manganeſe in making colourleſs pellucid glaſſes, for conſuming any accidental tinge. Larger proportions give a brown or black colour: hence its uſe in the compoſition of black enamels, and in the black glazings for earthen ware. The bright ſtriated ſort is generally preferred by the glaſs-makers, and the other by the potters.

Mr. Pott has given ſome experiments on this mineral (*Miſcellan. Berolinenſ. tom.* vi.) from which it does not appear to contain any Iron. He obſerves that it is not attracted by the magnet either in its crude ſtate, or after it has been expoſed to the fire in conjunction with inflammable ſubſtances; and that it yielded nothing metallic on being urged by a ſtrong fire with the common reducing flux.—With twice its weight of Nitre, it did not deflagrate; the mixture boiled up, ſoon after concreted into a blackiſh grey maſs variegated with yellow ſpots, leaving on ſome parts of the crucible a green or purpliſh glazing. The powdered maſs did not deliquiate in the air. On the affuſion of warm water, it acquired an elegant green colour, which was ſoon ſucceeded by a blue and a purple, and then returned into green again. On ſhaking the Glaſs the ſame beautiful ſucceſſions of colour repeatedly appear. The green ſolution, paſſed through a filter, and digeſted or boiled, loſes its colour, depoſiting a fine yellow powder, which calcines brown, diſſolves in acids, and is not precipitated by alcaline Salts.——The ſame phœnomena were obſerved on treating the Manganeſe with fixed alcalies inſtead of Nitre.——Acids have no effect upon crude Manganeſe, but partially diſſolve it when calcined. The ſolutions are colourleſs, except that made with Spirit of Vitriol, which has a ſlight roſe colour. On adding alcalies, a white earth is precipitated.——Sal ammoniac elevates nothing from it in ſublimation, but parts with a little of its own urinous ſpirit. The reſiduum, which appears of a reddiſh colour, partly diſſolves in water, leaving a whitiſh earth. The ſolution coagulates with alcaline Lixivia.——Calcined with Sulphur, it forms a yellowiſh brown maſs, which yields, with water, a large quantity of a white cryſtalline Salt, of a bitteriſh aſtringent taſte followed by a kind of ſweetneſs. This Salt yields in diſtillation a ſulphureous phlegm, and a little ammoniacal Sublimate, but no acid ſpirit. The reſiduum taſtes like burnt Alum, but more acid. A ſolution of the Salt efferveſces with alcalies, and depoſites a white earth. It does not change colour with Galls.

EMERY. hibited by the King of Spain. The cupreous ſort, to be likewiſe reddiſh, but more equal and free from veins, to hold no Gold or Silver, and to be found in Copper mines in Europe. The ferrugineous to be of a ſparkling whitiſh, a dark grey, or a blackiſh colour, to be found in rich Iron mines, and to be the leaſt valuable ſort.

Common. The common Emery, whatever be its colour, whether reddiſh, greyiſh, or blackiſh, is a compact ſtone, ſo hard as to cut Glaſs like the diamond; impregnated with Iron, and a very ſmall portion of Copper. It is met with in Norway, Sweden, England, Saxony and other countries. Bruckman relates that the Emery found at St. Georgenſtadt in Miſnia is ſuperior to the Spaniſh. Its uſes. It is uſed for cutting and poliſhing precious ſtones, for poliſhing Agate, Porphyry, Marble, Glaſs, metalline Specula, Iron and Steel, and the various utenſils and ornaments made of theſe kinds of ſubſtances. For theſe purpoſes the Emery is ground in mills, the powder paſſed through ſieves of different degrees of fineneſs, and thus divided into different ſortments, the fineſt of which are, for the nicer uſes, further divided by waſhing them over ſeveral times with water. The refuſe Emery, in grinding, or ſuch as has been uſed in poliſhing, is, in France, dried and kept apart under the name of *potée d'Emery*. Some have employed powdered Emery, from its power of poliſhing hard ſtones, as a dentrifrice: but for this uſe it is by no means proper, as it wears off the natural poliſh of the teeth. —It has been ſaid that Emery gives out ſome red matter on the whetſtone: where this has been obſerved, the Emery employed muſt have been the red kind, or a ſpecies of hæmatites; for the others yield only a grey colour on the ſtone.

Examined by fire. I have tried to ſmelt this mineral with the ſeveral fluxes uſed in aſſays for Iron, as alcaline Salt, Borax, Charcoal duſt, Pitch, Tallow, *&c.* but could not procure a fire ſufficiently ſtrong to fully maſter the refractory ſtony matter. Though there was not, however, any perfect Regulus of Iron obtained, there were abundance of particles which the Magnet attracted. Emery in its crude ſtate is not affected by the Magnet. All acids extract ſomewhat from the Emery, but none of them diſſolve one half of it. In each of the following experiments was employed half an ounce of the menſtruum, and ſixty grains of the powdered ſtone. Spirit of Nitre diſſolved only thirteen grains out of the ſixty; the ſolution looked ſlightly yellowiſh, the reſiduum of a pale brown. Spirit of Salt took up ſeventeen grains, and acquired a gold-yellow tincture, leaving the powder of a pale brown. Aqua regia diſſolved twenty grains, and acquired a like yellow colour, leaving a yellowiſh brown powder. Spirit of Vitriol diſſolved twenty-four grains; the liquor continued colourleſs, the reſiduum greyiſh brown. Oil of Vitriol ſeemed to act upon the powder, to corrode and render it white; but no true ſolution enſued. Fixed alcaline Lixivia had no effect; but volatile ſpirits extracted a blue tincture, and took up about half a grain out of the ſixty grains of Emery: the remaining powder looked reddiſh brown. Infuſions of Galls, mixed with Oil of Vitriol that had been digeſted on Emery, depoſited a white Precipitate; with the ſolution or extraction made with Spirit of Vitriol, a grey Precipitate; with the tincture in Spirit of Nitre, a brown one; with that in Aqua regis, a blackiſh brown; with the tincture made in Spirit of Salt, the liquor ſeemed at firſt to become inky, but, on ſtanding, the colouring matter precipitated.

EMERY.

By acids, &c.

The alchymiſts have expected extraordinary effects from this mineral, and pretended by its means to fix Mercury, to augment Gold, &c. They have mixed with Gold an *extractum ſmiridis*, and thus increaſed indeed the quantity, but proportionably debaſed the quality of the Gold; for the matter ſo introduced is by no means true Gold, and does not ſtand the teſts of that metal. An experienced artiſt obſerves, that on amalgamation with Mercury, the adventitious

Sophiſtication of Gold with *Smiris.*

EMERY. matter is ſeparated and thrown out, almoſt as Calamine is from Braſs by a like treatment, and thus diſcovers that it is of a different nature from Gold. There is no real Gold to be obtained from the European Emeries; that ſome ſhould be got from the Peruvian, is little wonder, native Gold being imbedded in that, as in the other ſtones in the Gold mines.

MAGNET. II. The LOADSTONE OR MAGNET: *Magnes, lapis Heracleus, lapis Herculeus, lapis Lydius, lapis Nauticus, Siderites.* This ſtone is externally of a blackiſh, a brown, or a browniſh grey colour; ſometimes compact, and moderately hard; ſometimes ſoft, porous, and brittle. The beſt I have ſeen were of a blackiſh hue, or at leaſt more of a brown than a grey, much reſembling old Iron. It is found in all the four quarters of the world, though not in each of the provinces into which they are ſubdivided; in the Eaſt-Indies, Ethiopia, Macedonia, Bœotia, *&c.* in Spain, France, Norway, Ruſſia, Scotland, England, Sweden, Italy, Pruſſia, Hungary, Bohemia, Lithuania, Germany; more particularly in Saxony and Sweden; ſometimes in diſtinct mines, but moſt frequently along with the common ores of Iron. In Saxony the beſt Magnets are met with at Ehrenfriederſdorf, Schwartzenberg, and Breitenbrunn. Theſe ſtones were formerly divided according to the different countries they were brought from; but this circumſtance is now diſregarded, the value depending wholly upon their qualities.

Its diſtinguiſhing characters. The diſtinguiſhing characters of the Loadſtone are, that it attracts Iron; and that when placed ſo as to move round with very little friction, as when ſuſpended by a thread, or laid on a piece of cork floating in water, a certain point or pole turns always northwards, and another oppoſite one ſouthwards. The firſt of theſe properties renders it uſeful to the chymiſt for diſcovering or ſeparating ſmall particles of Iron mixed with other matters: by the ſecond, it proves an invaluable guide to the ſeamen.

MAGNET.

Attractive power.

The Magnet attracts no other ſubſtance but Iron; and Iron only in its perfect metallic ſtate. It does not touch the calces or croci, or ſulphurated Iron, and acts but on few of the ores, till art has freed them from their Sulphur, or impregnated them with inflammable matter *(y)*. Henckel obſerves, that it attracts Iron when mixed with conſiderable proportions of ſundry other metals; of Gold, Silver, Copper, Braſs, Tin, Zinc, Biſmuth, and Arſenic; but diſcovers no action upon Iron that has any admixture of Regulus of Antimony. If Iron be mixed only ſuperficially, in filings, with any other metallic body, a cautious application of the Magnet will extract the Iron; though a vigorous Magnet, haſtily applied, will take up the filings of the other metal intermixed among thoſe of the Iron. If a Magnet be rolled in Iron filings, a few of the filings will adhere all over its ſurface; but they will be plentifully accumulated on two particular points of the ſtone, and theſe points are its poles. It attracts Iron without actual contact, and in differentmedia; in vacuo, in air, in water, with the interpoſition of various ſolid bodies, wood, glaſs, ſtones, metals, *&c.* The degree of attractive power differs in different Magnets. In the hiſtory of the French Academy for the year 1702, there is an account of a Loadſtone in Holland, which weighed but ten ounces, and lifted eighteen pounds, that is, above forty times its own weight. Tergazzi mentions a Magnet which lifted ſixty; and Boyle, one which lifty eighty times its weight. This laſt is probably the ſtone taken notice of

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(y) Action of the Magnet on Iron ores.] It is obſervable, that ſeveral of the hard ores of Iron, which are not affected in the leaſt by the Magnet in their natural ſtate, are vigorouſly attracted by it when moderately roaſted, though, without the contact of any inflammable, and without ſeeming to loſe any ſulphureous, matter: and that the calces of Iron, by ſlight roaſting with inflammable additions, are made to obey the Loadſtone, and revived into their metallic form, each particle appearing now to be perfect Iron; whilſt the calces of other metals are in no degree revived without being brought into fuſion. It is probably this *revival* of the calx of Iron that Macquer means, when he ſays it *melts* ſooner than Iron itſelf; for it does not melt at all in any degree of fire that can be excited in the furnace of the chemiſt.

MAGNET. of by father Bonanni (in the *Muſæum Kircherianum*, p. 293.) which weighed no more than two ounces, and ſuſtained ten pounds. I have myſelf ſeen ſome which bore four, ſix, eight, ten, twenty times their own weight. The largeſt I ever ſaw was one found in Devonſhire, and kept in the Muſeum of the Royal Society in London. This weighs ſixty pounds, but does not lift much, though it moves a compaſs needle at the diſtance of nine feet. The power is greatly increaſed by arming, as it is called, or uniting the virtues of both poles by means of flat pieces of Iron of a proper thickneſs. Lani relates, that he had a Magnet which, unarmed, lifted only fifty-four grains; but when armed, eight hundred and four. Schottus mentions a Magnet in the poſſeſſion of the grand Duke of Florence, which weighed twenty-nine pounds, and lifted ſixty-five. Manfredus Settala had one, which weighed but a pound, and lifted ſixty pounds. It may be obſerved, that the Iron, appended to the armature, adheres only by two points or lines, and will be retained rather more firmly when the ſurface is rounded, than when it is flat. If a circular plate of Iron be made to ſpin upon a table, and in that ſtate taken up by a Magnet, it continues ſpinning for a time as it hangs from the ſtone.

Communicative and repulſive power. The Magnet communicates to Iron drawn over one of its poles, both its attractive and directive power, without loſing any virtue itſelf: hence compaſs-needles, and magnetic Steel bars. The harder the metal the more difficultly it receives, and the longer it retains, the magnetic power. Each of theſe has two poles like the natural Magnets. Either pole attracts common Iron or Steel; but the North-pole of one Magnet repels the North-pole of another, whether natural or artificial; and the South-pole repels the South. Oppoſite poles attract each other. Iron rendered magnetic by one pole of a Magnet, has its virtue deſtroyed by touching it on the other. Iron is capable of being rendered magnetic, and ſtrongly ſo, without the aſſiſtance of any natural Loadſtone. See ſome curious papers on this ſubject in the Philoſophical Tranſactions.

MAGNET.

Directive power.

The direction of the Magnet or magnetic needle is not always in the plane of the true meridian; but declines towards the Eaſt or Weſt, more or leſs in different places, and in one place at different times. One end of a needle, when made magnetic, inclines below the horizontal plane. In northern latitudes it is the North, and in ſouthern ones the South-pole which dips.

Its power weakened and deſtroyed.

The virtue of Magnets is weakened by moiſture of every kind; by unctuous or oily ſubſtances; by all Salts, whether in a ſolid form or diſſolved; by being long kept in the neighbourhood of another Magnet, or without any charge of Iron; by the Iron in contact with the ſtone becoming ruſty. A Magnet reduced into powder, immediately loſes all its virtue, as ſome fragrant flowers loſe all their ſmell on being bruiſed. The powdered Loadſtone, far from being able to attract Iron, is ſcarcely itſelf attracted by a vigorous Magnet. How ridiculous then the practice, by ſome recommended, of mixing powdered Loadſtone in plaſters, for extracting Iron out of the fleſh!

Muſſchenbroek relates that the power of the Magnet is not deſtroyed by fire; that, on the contrary, a Magnet which has loſt its power by being pulveriſed, recovers it again, ſo as to adhere to a freſh Magnet, by reverberation in a ſtrong fire. That author appears, throughout his treatiſe on this ſubject, an able philoſopher and mathematician, but no chemiſt. The powdered Loadſtone is a ferrugineous ore, and is no more attracted than the common ores of Iron in their natural ſtate. By calcination, in contact with flame or inflammable matter, the Iron is revived into its metallic form, and the powder adheres to a Magnet, not as being itſelf a Magnet, but as being Iron.

MAGNET.

Examined by fire and menſtrua.

The Magnet calcines to a reddiſh brown colour; and melted with inflammable fluxes, yields a conſiderable portion of true Iron. Sal ammoniac ſublimed from it, elevates ſo much of the Iron as to acquire a yellow colour, in the ſame manner as when ſublimed from Iron filings. Spirit of Nitre totally diſſolved it into a yellow liquor, which, on ſtanding, depoſited a ſmall quantity of yellowiſh Precipitate, amounting to about a grain and a half from thirty grains of the ſtone. Spirit of Salt diſſolved only twenty-five grains out of thirty. Both the ſolution and undiſſolved powder appeared yellow. Spirit of Vitriol diſſolved fourteen grains out of thirty; and Oil of Vitriol corroded twenty grains into a white calx. No vitriolic cryſtals were obtained by evaporating the ſolution made in the vitriolic acid.

IV. TIN.

TIN.

Fuſibility.

TIN, *Jupiter*, is a white Silver-coloured metal, not at all ſonorous or elaſtic, a little harder than Lead, ſofter than any of the other metals, very ductile, ſo as to be beat into thin leaves (z). It is the lighteſt of all the malleable metals; being little more than ſeven times heavier than an equal bulk of water.

It melts in the fire before it grows red hot; and on continuing the fire, and frequently ſtirring the fluid metal, ſlowly calcines into a white powder (a).

(z) *Tin — ductile.*] Tin is commonly reckoned the leaſt ductile of all the malleable metals except Lead. In regard to ductility into wire, it certainly is ſo; but in regard to extenſibility into leaves, it is not. Theſe two properties ſeem to be leſs connected with one another than is generally imagined. Iron and Steel are drawn into exquiſitely fine wire, but cannot be beat into leaves. Tin, on the other hand, is beat into fine leaf, and cannot be drawn into wire. Gold and Silver poſſeſs both properties, the moſt eminently of all metallic bodies; whilſt Lead, notwithſtanding its flexibility and ſoftneſs, cannot be made either into leaves or wire of any fineneſs.

(a) *In the fire.*] It melts the moſt eaſily of all the metals; about the four hundred and thirtieth degree of Fahrenheit's thermometer. — Heated till almoſt ready to melt, it proves extremely brittle. Large blocks, are, in this ſtate, eaſily beat in pieces from a blow. The purer

Though Tin itſelf is ſo eaſy of fuſion, its calx is extremely refractory (*b*); not flying off in the fire, as Boerhaave pretends, but ſtanding the greateſt heat procurable in our furnaces, without melting, or ſuffering any alteration: even when mixed with fuſible vitreous matters, it does not perfectly melt with them, but renders a large proportion of the Glaſs opake and milky; nor is it eaſily reducible into Tin again.

TIN.

Though Tin, of itſelf, is ſo ſoft and ſo unſonorous, it ſurpriſingly improves the ſonorouſneſs, and deſtroys the ductility, of ſome of the other metals, particularly Gold, Silver, Copper, and Braſs. Bell-metal, the moſt ſonorous of all metallic bodies, is a compoſition of Copper and Tin. The minuteſt portion, even the vapour of Tin, renders many ounces and even pounds of Gold or Silver, ſo brittle as to fall in pieces under the hammer. The leaſt particle of Tin, falling on the ſtones or luting of a furnace, will make all the Gold and Silver melted in it, hard and brittle: from ſuch an accident, the Gold and Silver-ſmiths are obliged to pull down the whole furnace, and build a new one with freſh materials.

Effects on other metals.

Tin has been ſuppoſed by ſome to be nearly allied to Lead; as approaching to it in colour, ſoftneſs, fuſibility, and calcinability. The differences, however, are much greater than the reſemblances; Lead being far heavier than Tin; running eaſily into a tranſparent

Differences from Lead.

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purer ſort, from the facility of its breaking into long ſhining pieces, is called *grain Tin*. Melted, and nimbly agitated at the inſtant of its beginning to congeal, it is reduced into ſmall grains or powder.

In calcination, it contracts on the ſurface a browniſh grey powdery pellicle; which, on raiſing the fire to a cherry-red, ſwells and burſts, and diſcharges a ſmall bright white flame of an arſenical ſmell. The metal, when juſt calcined, appears of a duſky greyiſh or aſh colour: by a longer continuance of the fire, it becomes white, the more ſo in proportion as the Tin was the more pure.

(*b*) *Calx unfuſible.*] It is the moſt refractory of all metallic calces, that of Platina excepted. Even in the focus of large burning-glaſſes and mirrors, it only ſoftens a little, and forms cryſtalline filaments. With glaſs of Biſmuth, and the ſimple and arſenicated glaſſes of Lead, the moſt powerful fluxes known for refractory calces, it does not perfectly vitrify, forming only opake milky compounds. By this property it is fitted for making the baſis of the imperfect glaſſes called enamels.

Glaſs, whilſt Tin does not vitrify at all; not producing in the malleable metals that remarkable brittleneſs, which has procured Tin the title of *diabolus metallorum.*

Tin and Iron expoſed to a burning-glaſs.

Tin, the moſt fuſible, and Iron, the moſt refractory, of all the metals, unite eaſily with one another, and ſeem to have a great affinity (*c*). On mixing them in the focus of Tſchirnhaus's burning-glaſs, I obſerved, that when the Tin was melted firſt, and the Iron added, they united together very quietly; but that when the Iron was melted firſt, the addition of Tin occaſioned a crackling, and a ſputtering of little globules, which burſt with a conſiderable ſnap: inſtead of fumes, there aroſe exceeding fine filaments, which ſtuck to the clothes, *&c.* like cobwebs.

Tin deflagrates ſtrongly with Nitre, and alcaliſes the Salt. The filings, held in the flame of a candle, yield a ſmell reſembling that of Garlic, and thus appear to contain an arſenical matter (*d*): hence the ill effects of Tin on thoſe who are much expoſed to its vapours.

Tin

(*c*) *Affinity of Tin and Iron.*] Iron is diſſolved by melted Tin, in a heat far leſs than that in which Iron by itſelf melts: the compound is white and brittle. Iron, added to a mixture of Lead and Tin in fuſion, takes up the Tin, leaving the Lead at the bottom: and, in like manner, if Lead, Tin, and Silver are melted together, the addition of Iron will abſorb all the Tin, and the Tin only. Hence we are furniſhed with a method of purifying Silver from Tin, and conſequently of preventing the inconveniencies which this metal conſtantly occaſions in the refining of Silver by cupellation with Lead.

(*d*) *Tin and Arſenic.*] Tin melted with Arſenic falls in great part into a whitiſh calx: the part which remains uncalcined proves very brittle, and appears of a white colour, and a ſparkling plated texture, greatly reſembling Zinc. The Arſenic is very ſtrongly retained by the Tin, ſo as ſcarce to be totally diſſipable by any degree of fire: though the mixture be urged for a length of time, with a very intenſe fire; the Tin, afterwards recovered by fuſion with inflammable fluxes, diſcovers, by its appearance, by its brittleneſs, and by its augmentation of weight, that it ſtill holds a conſiderable portion of the Arſenic. Hence, as the common Tin ores abound with Arſenic, the common Tin is found alſo, upon experiment, to participate of that mineral.——Henckel diſcovered a method of ſeparating actual Arſenic from Tin; namely, by ſlowly diſſolving the Tin in eight times its quantity of an Aqua regia made with Sal ammoniac, and ſetting the ſolution to evaporate in a gentle warmth: the Arſenic begins to concrete whilſt the liquor continues hot, and more plentifully on its growing cold, into white cryſtals. Mr. Marggraf, in the Berlin Memoirs for the year 1747, has given

TIN.

Solution in different acids.

Tin diſſolves in all the mineral acids. For its diſſolution in the vitriolic, it requires the acid to be highly concentrated, and aſſiſted by a boiling heat: the inflammable principle of the Tin, extricated during the diſſolution, unites with a part of the acid into a true Sulphur; which ſublimes, in its proper form, into the neck of the retort.

The nitrous acid acts upon Tin much more eaſily: to obtain a perfect ſolution, the metal muſt be added, by a very little at a time, and all heat avoided: if much of the Tin is put in at once, it will only be corroded into a white powder, or reduced into a thick gelatinous ſubſtance; and if the ſolution when made, be conſiderably heated, the diſſolved Tin will ſeparate again in the like forms of a powder or jelly.

The marine acid has the greateſt affinity with Tin of all the acids, but does not diſſolve it without heat: it forſakes Mercury to unite with Tin, and when thus combined with it, volatiliſes a conſiderable portion of the metal: a ſtrong ſmoking ſpirit diſtils, which, if diluted with water, grows milky, and depoſites the Tin. This ſpirit, commonly diſtinguiſhed by the name of its inventor Caſſius, is prepared, by amalgamating three parts of Tin with five of Mercury, grinding the Amalgam with eight parts of Mercury

given a more particular account of this proceſs: he obſerves that the white ſediment, which at firſt ſeparates during the diſſolution, is chiefly arſenical: that Malacca Tin, which is accounted one of the pureſt ſorts, yielded no leſs than one fourth its weight of arſenical cryſtals; that ſome ſorts yielded more; but that Tin, extracted from a particular ore which held no Arſenic, afforded none. That the cryſtals were truly arſenical, appeared from their being totally volatile; from their ſubliming (a little fixed alcaline Salt being added to abſorb the acid) into a colourleſs pellucid concrete: from the Sublimate, laid on a heated copper-plate, exhaling in fumes of a garlic ſmell; from its ſtaining the Copper white; and from its forming with Sulphur a compound ſimilar to the yellow or ſulphurated Arſenic. He found that the Arſenic was ſeparable alſo by means of Mercury: an amalgam of Tin being long triturated with water, and the powder which was waſhed off committed to ſublimation, a little Mercury came over, and bright arſenical flowers aroſe into the neck of the retort.—Theſe curious experiments are here inſerted intirely upon the credit of the authors.

Common Tin makes a crackling noiſe in bending: this is commonly ſuppoſed to be an eſſential property of pure Tin, but poſſibly it may belong only to ſuch as is arſenicated; for thoſe operations by which Arſenic is ſaid to be ſeparated, deprive it of its noiſe.

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Mercury ſublimate, and diſtilling the mixture in a retort: the reſiduum of this operation, treated with Nitre, is the *ſudoriferum maximum* of Faber, a title which it does not very properly deſerve. Some affirm, that a ſmoking ſpirit may be obtained by putting Tin into butter of Antimony; but this does not ſucceed.

Aqua regia, or a mixture of the nitrous and marine acids, diſſolves Tin more perfectly than the one, and more readily than the other: when the nitrous has let the Tin fall in form of a white powder, if a little of the marine be added, and a moderate heat applied, the Precipitate will be taken up again, and kept diſſolved. An ounce of Spirit of Sea-ſalt, mixed with only a ſcruple of Spirit of Nitre, diſſolved Tin perfectly: but, upon inverting the proportions, and taking a ſcruple of marine to an ounce of the nitrous acid, the mixture, with four ſcruples or four and a half of Tin, became thick like pap: ſome more of the marine acid being gradually added, the whole was diſſolved into a clear liquor. In making the ſolution with theſe mixed acids, a ſmall portion of blackiſh matter commonly ſeparates, and falls to the bottom *(e)*.

Vegetable acids, as diſtilled Vinegar, do not diſſolve any ſenſible quantity of Tin: and hence I have been led to ſuſpect, that thoſe who order a Salt to be made from Tin by diſtilled Vinegar, as all chemiſts do, have been impoſed on by taking Tin alloyed with Lead; and that, inſtead of a Salt of Tin, they obtained no other than a Sugar of Lead. Pure Tin I have digeſted, boiled, and treated in many different ways with Vinegar; and the ſame experiments I have repeated with pure calx of Tin, which ſome prefer, for

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(e) Solution of Tin.] The ſolution is ſometimes colourleſs, ſometimes of a bluiſh, and ſometimes of a bright yellow colour, according to different circumſtances in the proceſs. Mixed with red infuſions or decoctions of animal or vegetable ſubſtances, it greatly improves their colour: the dull red of Cochineal is heightened, by a ſlight addition of this liquor, into ſcarlet; that of Brazil wood into a lovely crimſon. The ſolution of pure Tin ſcarcely exhibits any appearance of cryſtals; and, if inſpiſſated to dryneſs, deliquiates in the air.

for this uſe, to the crude metal: but I never could obtain any thing ſaline, except an unctuous kind of extract; and the Tin employed retained its original weight.—This metal is corroded by fixed alcaline Salts, whether melted along with them, or boiled in a ſolution of them.

Foils for Specula. Tin, amalgamated with Mercury, is uſed as a foil for looking-glaſſes, &c.—The Amalgam mixed with Sulphur and Sal ammoniac, and ſet to ſublime, yields a ſparkling Gold-coloured ſubſtance, called *Aurum Moſaicum*, uſed in England as a pigment: this preparation is commonly made from Quickſilver and Tin, of each two parts, amalgamated together, and then thoroughly mixed with Sulphur and Sal ammoniac, of each one part and a half: after ſublimation the *Aurum* remains at the bottom.——Calx of Tin is employed for poliſhing Glaſs, Steel, &c. and makes the baſis of the white glazing of earthen-ware, and the white enamels: a portion of Lead is commonly mixed with the Tin, that metal remarkably promoting its calcination: the compound calx is called *Putty*. Tin may be ſtill more expeditiouſly calcined, by means of Nitre or of common Salt: when the laſt is uſed, the metal in fuſion muſt be kept conſtantly ſtirring; and, in either caſe, the calx muſt be well edulcorated with water.——In the detonation of Tin with Nitre, white flowers ariſe, which, collected in aludels, have been employed by ſome as a coſmetic: magiſteries or precipitates of the metal have been uſed alſo in the ſame intention. Le Mort relates, that a Salt is obtainable, by diſtilled Vinegar, much more eaſily from the flowers, than from Tin in ſubſtance, or its calx: but I have never been able to obtain this Salt from thoſe, any more than from theſe.——The ſolution of Tin in Aqua regia is uſed as a precipitant for Gold; and the golden calx thrown down by it, for making the ruby Glaſs; an account of which may be ſeen in Kunckel's *Laboratorium*. See Gold.

Aurum Moſaicum.

White enamels, &c.

Coſmetic preparations.

Ruby Glaſs.

Medical hiſtory. Tin has been ſuppoſed to poſſeſs conſiderable medicinal virtues; and even Boerhaave is greatly prejudiced

TIN. diced in its favour: he ſays, the Calx, which precipitates ſpontaneouſly from its ſolution, is of ſingular efficacy in hypochondrical and heſterical ſuffocations. To ſuch a character this metal has no pretence; nor is the internal uſe of any of its preparations adviſable.

There are two preparations of it ſtill met with, at times, in the ſhops, though they little deſerve a place there; namely, the *antihecticum Poterii*, and *bezoardicum joviale*. The antihectic is made from equal parts of Tin and Regulus of Antimony, melted together, then pulveriſed, mixed with twice or thrice their quantity of powdered Nitre, injected into a red-hot crucible, and, after the deflagration, edulcorated and dried. The bezoardic differs from this only in the manner of preparation; the mixture of Regulus of Antimony and Tin being reduced to a calx, not by detonation with Nitre, but by ſolution in acids, after the ſame manner as the *bezoardicum minerale*.

Natural hiſtory. The largeſt quantities of Tin are met with in England, particularly in the county of Cornwall. There is ſome alſo in Bohemia and Saxony, and a little in the Eaſt-Indies: but in other countries, it is rare to find ſo much as to be worth the trouble of extracting. Britain is ſuppoſed to have received its name from its abounding with this metal; Tin being called in the Syriac and Chaldaic languages *Bragmanack*, that is, the kingdom of Jupiter; whence are deduced, *Bratman*, *Britman*, *Britannia*. The ores of Tin are, (1.) *Zinngraupen*, or cryſtalline maſſes, commonly of a poliſhed ſurface, ſometimes of a dark brown, or violet colour, but chiefly blackiſh: theſe are the richeſt of the Tin ores. (2.) *Zwitter*, or cryſtalline concretions reſembling the foregoing, but of a yellowiſh or ruſty colour, and leſs rich. (3.) *Zinn-ſtein*, Tinſtone, much poorer in Tin, and intermixed with a much larger proportion of ſtony and other mineral matters. (4.) Tin ore participating of Iron, called by the miners *Wolffram* (*f*).——Aſſays of Tin ore are made, in the common manner, with black flux. In the large way, the richer ores are barely melted down among the fuel; the poorer are previouſly ſtamped and waſhed.

The Engliſh and Malacca Tin are much purer than the Saxon, Bohemian, or ſuch as is prepared in any other country, but they are very rarely to be met with, at leaſt in their pure ſtate. In Holland, every Tin-founder has Engliſh ſtamps; and whatever his Tin be, the inſcription *Block Tin* makes it paſs for Engliſh. The Engliſh Tin is never worked, in England itſelf, without addition: all the wrought Tin imported from thence, we may be ſure, has an admixture of ſome other metal: the unwrought may be looked upon as unalloyed.

Pewter.

The ſubſtances mixed with Tin are various; and every workman keeps his mixture a ſecret: ſome are greatly ſuperior to others: I remember ſome perſons in England, not above three, whoſe Pewter was hard and ſonorous, and almoſt of a Silver whiteneſs. In England, I rarely found any Lead in Pewter, though we [in Germany] employ it in a large proportion: the Engliſh ſeem to avoid that metal, and very juſtly, as it injures the ſound and the colour of the Tin, and renders the veſſels made from it apt to communicate dangerous qualities to any kind of acid liquors or foods. The compoſition of the more eſteemed kinds of Pewter is worthy of a chemical enquiry: without knowing their compoſition, the workman can never imitate them; and that can be determined only by chemical experiments, unleſs chance ſhould make the diſcovery. The principal ſubſtances made uſe of are, martial Regulus of Antimony, Zinc, Biſmuth, Copper,

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(*f*) *Tin ore.*] Tin is rarely or never found native in the earth. Its ores are generally met with in ſmall maſſes, ſeldom exceeding two or three ounces in weight, intermingled with a large proportion of earthy matter. They are of an angular figure, moderately hard, and remarkably heavy: the richer ſorts are heavier than pure Tin itſelf. Their colour is moſt commonly brown or blackiſh: ſometimes, but very rarely, they are white and ſemitranſparent.

per, Iron, Princes-metal: each of theſe, or two or three of them mixed together, make the Tin hard and ſonorous, and of a whiteneſs approaching to that of Silver; but much depends on the proportion: of ſeveral of them, two or three pounds are ſufficient for an hundred weight of Tin. The Dutch put a whole pound of Lead to ten pounds of Tin.

The workmen have two methods of diſtinguiſhing the admixtures of Lead with Tin, and judging of the quantity of Lead. The firſt is by biting it with the teeth: pure Tin makes a crackling noiſe, and the more Lead it holds the leſs it crackles. The other is, by caſting a ball of pure Tin, and another of the Tin to be examined, in the ſame mould: the more this laſt bullet exceeds that of the pure Tin in weight, the more Lead it contains (g). Lead may be diſcovered alſo by vegetable acids, as diſtilled Vinegar, Lemon-juice, &c. which diſſolve Lead, and have ſcarcely any action on pure Tin.

CLASS

(g) *Examination of the purity of Tin by weight.*] Dr. Brandt has given a paper in the Swediſh Tranſactions (1744) proving, from experiment, that the fineneſs of worked Tin may be aſſayed with great accuracy from its weight, without melting, or injuring the figure of the veſſel. He found that a piece of fine Tin, weighing in the air 531 grains, loſt in water $75\frac{1}{2}$: that a piece of four-ſtamped Tin, of the ſame weight (compoſed according to the royal ordonnance, of 97 parts of fine Tin and 3 of Lead) loſt in water $72\frac{1}{2}$: that the ſame weight of thrice-ſtamped Tin (in which the proportions are 83 of fine Tin to 17 of Lead) loſt in water $68\frac{1}{2}$: and that the ſame quantity of double-ſtamped Tin (conſiſting of $66\frac{1}{3}$ Tin and $23\frac{2}{5}$ Lead) loſt 64. Upon theſe principles, when wrought Tin was brought to be aſſayed, inſtead of taking off any part of the veſſels for an experiment by fuſion, he weighed them entire in air and in water: when the loſs in water was proportionably leſs than that of the ſtandard bar, they were judged to contain too much Lead, and a further examination always ſhewed that they did. He obſerves that this method has one great advantage in common buſineſs, that large utenſils are aſſayed to a greater degree of nicety than ſmall ſpecimens; the accuracy depending on the ſenſibility of the balance, and large balances being more ſenſible, or turning with a leſs weight in proportion to the whole quantity they are loaded with, than ſmall ones: a good aſſay balance did not turn with leſs than the 7000th part of the weight upon each arm; whilſt an ordinary large balance, which bore on each arm 800 pounds, turned, when loaded, with the 25600th part of that weight.

CLASS III. SEMIMETALS.

Metallic bodies not bearing the hammer; volatile in the fire.

I. MERCURY, *or* QUICKSILVER.

MERCURY. Its general properties.

MERCURY is a fluid metallic ſubſtance, not moiſtening the hands; perfectly opake; of a bright ſilver-colour, reſembling Lead or Tin when melted; entirely void of taſte and ſmell; extremely diviſible (*h*); not congealable in the greateſt degree of cold hitherto known (*i*).

It is the moſt ponderous of all fluids, and of all known bodies except Gold [and Platina:] its gravity is to that of water nearly as 14 to 1; a cubic foot of Quickſilver weighing 947 pounds, whilſt a cubic foot of water weighs but 70: it is found to be heavier in winter than in ſummer, in proportion of eleven ounces thirty-two grains, to eleven ounces ſeven grains. In conſequence of its great denſity, it is of all fluids the coldeſt to the touch: the hand cannot be kept one quarter of an hour in a quantity of Quickſilver with ſafety. Of all fluids likewiſe it grows hotteſt, (not really, but apparently) from the application of an equal external heat.

(*h*) *Mercury, extremely diviſible.*] In ſmall drops, it aſſumes a ſpherical figure. The globules divide, from the ſlighteſt touch, into numerous ſmaller ones, each further diviſible by the ſame means: the minuteſt that can be diſtinguiſhed, by the naked eye, or microſcopes, appear perfect ſpecula, very vividly reflecting the images of neighbouring objects. They loſe their ſphericity if placed upon certain metals, particularly Gold; on which the mercurial globules ſpread themſelves, like water upon moiſt bodies, and thus diſcover their great affinity with it. This fluid may be ſtrained, by moderate preſſure, through the pores of leather; and thus freed from duſt or other like impurities that may be accidentally blended with it.

(*i*) *Not congealable.*] Though it never has been known to become ſolid from cold, it has ſometimes been obſerved, in very intenſe colds, produced by artificial mixtures, to loſe conſiderably of its fluidity. There is an inſtance, in the *Acta naturæ curioſorum, tom.* vii. of its acquiring the conſiſtence of a ſoft Amalgam, or a mixture of Mercury with one fourth its weight of Lead or Tin.

MERCURY.

In a heat below ignition, it totally exhales in extremely thin, ſubtile, penetrating fumes, which condenſe into running Mercury again. The admiſſion of air, which changes the fumes of the other ſemimetals into a powdery calx, has not that effect upon thoſe of Quickſilver *(k)*.

It

(k) Change—into calx.] This ſemimetal is nevertheleſs convertible, if not into a true calx, yet into the appearance of one, by a long continuance of a heat juſt not ſtrong enough to diſſipate it. By degrees it changes into a powder, at firſt aſh-coloured, afterwards yellow, at length of a bright red colour, and of an acrid taſte. —— This proves leſs volatile in the fire, than the Mercury in its fluid ſtate. It ſupports, for a time, even a degree of red heat. In the focus of a burning-glaſs, it is ſaid, if expoſed upon a tile, to vitrify, on a piece of charcoal to revive into running Mercury, before it exhales. Evaporated by common fire, it leaves a ſmall portion of a light brown powder; which, as Boerhaave relates (in the Philoſophical Tranſactions) bore a blaſt heat, ſwelled into a ſpongy maſs, formed with Borax a friable vitreous ſubſtance, but in cupellation vaniſhed.

By a heat no greater than that of the human body, or even of boiling water, though continued for ſome years, only a ſmall portion of the Mercury is converted into powder. The powder thus obtained appears of a dark greyiſh or black bolour. Conſtant triture, or agitation, produce a change ſimilar to that effected by this low degree of heat, and in a far ſhorter time.

As Mercury aſſumes theſe adventitious forms, without communication with the air, or the loſs of any of its parts, it recovers its own without addition. Both the red and the black powders, expoſed barely to a fire ſufficiently to elevate them, return into fluid Mercury again. The red powder has been revived into Quickſilver by ſimply grinding it in a glaſs mortar.

Repetitions of theſe operations occaſion no permanent change in the Quickſilver. Boerhaave had the patience to diſtil Mercury five hundred and eleven times ſucceſſively; to keep it in conſtant agitation for many months; to digeſt it, for upwards of fifteen years together, in low degrees of heat, both in open and cloſe veſſels, by itſelf and in conjunction with other metallic ſubſtances; and received from all his labours only this reſult, that Mercury is not by any of thoſe means to be changed. It were to be wiſhed, that this indefatigable enquirer had purſued proceſſes more agreeable to the general doctrine of thoſe who pretend to have changed it. It is not by low degrees of heat, but by the ſtrongeſt it can ſuſtain, that the philoſophers by fire think to lay fetters on this fugitive metal.

Dr. Brandt amalgamated fine Gold with a large proportion of Quickſilver, and having ſtrained off the ſuperfluous Mercury, digeſted the Amalgam, in a cloſe ſtopt veſſel, for two months, with ſuch a heat, that a part of the Quickſilver ſublimed into the neck of the Glaſs. The matter being then ground with twice its weight of Sulphur, and urged with a gradual fire in a crucible, a ſpongy calx remained, which being melted with Borax, and afterwards kept in fuſion by itſelf for half an hour in a very violent fire, ſtill retained ſo much of the

Quickſilver,

MERCURY.

It diſſolves in all the mineral acids, but with different degrees of facility; and proves itſelf a menſtruum

K 4

A menſtruum of metals.

Quickſilver, as to prove brittle under the hammer, and appear internally of a leaden hue. The metal being amalgamated with freſh Mercury, the Amalgam again ground with Sulphur, and expoſed to an intenſe fire, a ſpongy calx remained as before. —— This calx being digeſted in two or three freſh parcels of Aqua regia, a ſmall portion of whitiſh matter remained at laſt undiſſolved. The paper which covered the cylindrical Glaſs wherein the digeſtion was performed, contracted from the vapours a deep green circular ſpot in the middle, with a ſmaller red one at the ſide; whereas the Aqua regis digeſted in the ſame manner by itſelf, or with Gold, or with Mercury, gave no ſtain. The firſt ſolution, on the addition of Oil of Tartar per deliquium, grew red as blood; on ſtanding it depoſited, firſt a little yellow calx like Aurum Fulminans, afterwards a bright matter like fine Gold, and at laſt a paler Precipitate inclining to green; its own deep red colour and tranſparency continuing unchanged. Being now committed to diſtillation, a colourleſs liquor aroſe; and the reſiduum, perfectly exſiccated, yielded on edulcoration a yellow calx of Gold, which the alcaline Lixivium had been unable to precipitate. The ſecond ſolution turned green on the admixture of the alcaline liquor, and let fall a white Precipitate, which edulcorated, looked black and brown. —— The ſeveral precipitates were calcined with twice their weight of Sulphur, and then melted with four times their weight of Flint and twelve of Pot-aſh, in a fire vehemently excited by bellows. The ſcoria appeared of a golden colour, which on pulverization and edulcoration vaniſhed. At the bottom was a Regulus, which looked bright like the pureſt Gold, but was not perfectly malleable. Broke, it appeared internally white, and the white part amounted to at leaſt one third its bulk. Beſides this lump of metal, there were ſeveral ſmaller ones, white like Silver, and ſoft as Lead. —— This remarkable experiment was made in the Royal Elaboratory at Holm, and communicated in the *Acta literaria ſueciæ* for the year 1731. The author concludes from it, that a portion of Quickſilver, and a very conſiderable one, is detained and fixed by digeſtion with Gold, ſo as not to be diſſipable by the moſt intenſe fires. He expreſsly mentions the Gold, made uſe of, being highly refined; and though he does not inform us what the Mercury was, it ſeems hard to ſuſpect that this accurate and expert chemiſt ſhould employ, for ſuch a curious purpoſe, Mercury whoſe purity from Lead, or the other ſubſtances with which it is ſometimes ſophiſticated, he had not duly examined.

Some have pretended to convert Quickſilver into a limpid water, capable of diſſolving metals, and producing extraordinary effects on them. This is attempted by expoſing the Mercury to the ſudden action of a ſtrong fire. A tall Iron veſſel, furniſhed with a capacious head, aludels, and a recipient, is heated to a white heat, and the Quickſilver injected, by a very ſmall quantity at a time, through an aperture made for that purpoſe near the top. Kunckel has ſhewn the fallacy of this proceſs; that the liquor ſometimes collected in the receiver is no other than a merely aqueous one, accidentally contained in the Mercury or forced out from the luting, in no reſpect different from common water. I have oftener than once repeated the experiment with pure dry Mercury, without being able to obtain the leaſt appearance of any moiſture.

MERCURY.

ſtruum for ſundry metallic bodies (*l*). It has the greateſt affinity with Gold; adhering to and diſſolving that metal the moſt readily of all. It unites alſo with Silver;

(*l*) *A menſtruum for metals.*] There are three metallic bodies, which Mercury does not diſſolve or unite with; Iron, Arſenic, and the ſemimetal called Nickel. It will in ſome caſes abſorb metals, particularly Gold and Silver, from their ſolutions both in acid and in alcaline liquors; but does not act upon any metal when combined with Sulphur, nor on precipitates made by alcalies, nor on calces prepared by fire. Whatever metal it is united with, it conſtantly preſerves its own white colour.

Saline liquors diſſolve only a certain quantity of metals; which they carry with them through all the ſtrainers that the liquor is capable of paſſing by itſelf. Mercury unites with any proportions, forming, with different quantities, amalgams of different degrees of conſiſtence. From the fluid ones greateſt part of the Quickſilver may be ſeparated by colature. Biſmuth is the only metallic body, which is ſo far attenuated by Mercury, as to paſs through leather with it in any conſiderable quantity; and Lead is the only one, to which Biſmuth communicates that property in any conſiderable degree.

Biſmuth promotes the action of Mercury upon Lead in a remarkable manner. Quickſilver impregnated with one fourth, one eighth, one twelfth its weight of Biſmuth, diſſolves maſſes of Lead, in a gentle warmth; without the agitation, or triture, or comminution, or melting heat, neceſſary for uniting Lead with pure Mercury. Theſe experiments I made, ſome years ago, on a report, that an eminent French ſurgeon had diſcovered a ſafe menſtruum for diſſolving pieces of Lead lodged in cavities of the human body.

On triturating or digeſting amalgams for a length of time, a blackiſh or duſky coloured powder ariſes to the ſurface, and may be readily waſhed off by water. Some of the chemiſts have imagined, that the amalgamated metal is here reſolved into its conſtituent parts. But pure Mercury, as we have already ſeen, is convertible by itſelf, on the ſame treatment, into a ſimilar powder; and the metallic particles, united in this proceſs with the mercurial powder, are found to be no other than the metal in its entire ſubſtance. Some metals ſeparate much more ſlowly and difficultly than others; Gold and Silver the moſt ſo.

It is ſaid that the Quickſilver, in theſe powders, proves more volatile than in its common fluid ſtate; that if the powder, which ſeparates from an amalgam of Lead, be committed to diſtillation with Vinegar in a tall veſſel, the Mercury will riſe before the Vinegar boils; that by a like artifice, Quickſilver may be made to diſtil even in a leſs degree of heat than that of the human body. This I relate upon the authority of Boerhaave; having never been able myſelf, though the trials were often repeated, to ſucceed.

On expoſing amalgams to a fire gradually raiſed to ignition, the Mercury freely exhales, leaving the metal behind in form of a very ſubtile powder. A ſmall portion of ſome of the metals generally ariſes along with the Quickſilver. Thus Mercury diſtilled from Lead, Biſmuth or Tin, appears leſs bright than before, ſtains paper black, ſometimes exhibits a ſkin upon the ſurface, and does not run freely or into round globules. Boyle relates, that he has obſerved the weight of the Mercury

Silver; leſs eaſily with Lead; ſtill leſs ſo with Tin; very difficultly with Copper; moſt difficultly of all with Iron, to which it ſeems to have inſuperable repugnance. It does not eaſily take up Biſmuth or Regulus of Antimony, unleſs they are previouſly mingled with other metals, or diſpoſed to unite with it by particular managements. After it has been combined with either of theſe, it throws them out again upon digeſtion. Biſmuth nevertheleſs diſpoſes ſome other metals, particularly Lead, to ſuch an intimate union with Mercury, as to paſs along with it through the pores of leather. Quickſilver mingles alſo with various ſaline ſubſtances, and with Sulphur; with which laſt it forms a black maſs called *æthiops*, which changes on ſublimation, into a red one called Cinnabar.

How to be kept.

The gravity and diviſibility of Mercury renders great precaution neceſſary in regard to the veſſels in which any conſiderable quantities are exported or kept; the ſmalleſt hole or crack permitting it to eſcape. Metalline veſſels are improper; and glaſs or earthen ones are too liable to break. The veſſels commonly made uſe of are, either compact wooden ones; or ſtrong thick leather, in which all the Spaniſh Mercury is brought from America; or thick glaſs bottles, or turned wooden boxes ſecured in leather.

See Patten
Evid
See Boyle

Methods of judging of its purity.

There are ſundry methods mentioned in books for judging of the goodneſs of Quickſilver; but they ſeem to be built upon vain conceits about the Mercuries of metals. Some direct the Quickſilver to be expoſed

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Mercury ſenſibly increaſed by diſtillation from Lead, and this when only a moderate fire was made uſe of.

Mercury amalgamated with ſtellated Regulus of Antimony, digeſted for ſome hours and then diſtilled off, is ſaid to become, by a few repetitions of the proceſs, more ponderous and more active; the animated or philoſophic Mercuries of ſome of the alchymiſts, are ſuppoſed to have been Quickſilver thus prepared. By the ſame or by ſimilar proceſſes ſeem to have been obtained the curious Mercuries which Boyle declares he was in poſſeſſion of and made himſelf; which "were conſiderably "heavier in ſpecie than common Quickſilver — diſſolved Gold more "readily — grew hot with Gold, ſo as to be offenſive to the hand — and elevated Gold in diſtillation." See his producibility of chemical principles, p. 209, &c. and the Philoſophical Tranſactions, No. 122.

MERCURY. poſed to the fire, and the colour of its fumes examined. Green or yellow fumes denote a ſolar, bluiſh ones a lunar, and reddiſh brown a venereal Mercury. A jovial Mercury is diſtinguiſhed by a whitiſh colour of the fumes, a ſaturnine by an aſh-grey colour, and a martial by a dark yellow. Others, diſregarding the fumes, attend only to the ſpot which remains upon evaporating ſome of the Quickſilver in a Silver ſpoon. If the ſpot is yellow or white, the Mercury is held to be good, the yellow colour being ſuppoſed to proceed from Gold, and the white from Silver. A brown or black ſpot on the other hand is a mark that the Mercury is of a bad kind; theſe colours proceeding from Copper or ſome of the baſer metals.

We need not however be ſolicitous about the colour either of the fumes or the reſiduum. If any powdery or any actual matter at all is left, we may be ſure that the Quickſilver is adulterated, moſt probably with Lead; a conſiderable portion of that metal being miſcible with Mercury, by the mediation of Biſmuth, not only without deſtroying its fluidity, but ſo as to paſs with it, by preſſure, through leather. It is not needful to ſuffer the Mercury to exhale in the air, in order to diſcover its adulteration; it may be all ſaved, by diſtilling it in a retort. If it totally ariſes, without leaving any reſiduum, we may be ſatisfied of its purity. The abuſe may be detected alſo ſtill more commodiouſly and expeditiouſly, without a retort, or a Silver ſpoon, or a crucible, or fire. If a little of the Quickſilver be diſſolved in Aqua fortis, a white precipitation will preſently betray the Lead. The external marks of its purity are its whiteneſs and brightneſs, and the facility of its running when a little is dropped on a table, *&c.* The marks of its impurity are, its appearing duſty, contracting a ſkin on the ſurface, running ſlowly, and leaving a droſſy matter behind.

Purification. There are different methods of purifying Quickſilver; as ſtraining through leather; trituration or ablution with Vinegar, with Vinegar and Salt, with

Sope-

MERCURY.

Sope-leys, with rectified Spirit of Wine, and with Aqua fortis; and diſtillation, either without addition, or with alcaline Salts, Quicklime, or Iron filings. When Quickſilver is only ſuperficially mixed with duſt or earthy powder, ſtraining through leather is ſufficient for its purification. If any foulneſs ſtill remains, Spirit of Wine will waſh it off. Unctuous or oily impurities require ablution with Sope-leys. Lead and Biſmuth are moſt effectually ſeparated by making the Mercury into an *æthiops* with a ſufficient quantity of Sulphur, and reviving it again from the *æthiops* by diſtillation with twice its quantity of Quicklime, alcaline Salt, or Iron filings. The Mercury alone will diſtill, and leave all its impurities behind. Sulphureous, antimonial, and other like admixtures are to be ſeparated by the ſame means. The purification by Aqua fortis is performed by taking only a ſmall quantity of the acid to a large one of Mercury; grinding them diligently together, and then waſhing the Quickſilver with water. When Mercury is combined with Sulphur into Cinnabar, the revivification of it does not well ſucceed with alcaline Salts; by fixed alcalies, the Sulphur is very difficultly, and not perfectly, abſorbed; to volatile alcalies it does not yield at all. On the other hand it is obſervable, that metallic bodies, as Iron, Lead, Tin, Regulus of Antimony, readily detain the Sulphur in diſtillation, and ſuffer the Mercury to ariſe pure.

Uſes.

The largeſt quantities of Mercury are employed for metallurgical operations. Gold and Silver are extracted, in the Spaniſh Weſt-Indies, from their ores or matrices, by amalgamation with Mercury; and both metals are recovered by the ſame means, when blended in minute particles with earthy matters, as in filing or working them. Amalgamated with Tin, it makes the foil for looking-glaſſes, and reflecting balls. It is uſed alſo for gilding on Silver, for anatomical injections, for weather-glaſſes, and ſundry other purpoſes. In vacuo, it appears luminous, and is then called the mercurial Phoſphorus.

Quick-

MERCURY.

Medical hiſtory.

Quickſilver, conſidered as a medicine, is a ſpecific againſt the venereal diſeaſe, worms, lice, and all kinds of inſects. The venereal diſtemper is not perhaps to be radically cured without it, but againſt inſects there are other remedies equally if not more effectual. It is commonly ſuppoſed to have, of itſelf, no poiſonous quality; but appears, from experience, manifeſtly prejudicial to the nerves and the bones. Its ill effects are moſt obſervable in thoſe, who are expoſed to its fumes; which fumes are no other than perfect Quickſilver, as any one may be convinced by receiving them on a piece of moiſt leather or cloth, upon which they will reunite into little globules of Mercury. Moſt people admit a pernicious quality in the fumes, though they deny it in the Quickſilver; not conſidering that the fumes are only the Quickſilver itſelf, divided but not altered by the heat. Even mercurial ointments applied externally have occaſioned contractions of the limbs, corroſions of the bones, and other dangerous conſequences. How ſoon do the miners feel its ill effects, though they neither anoint with it, nor ſwallow it, nor are expoſed to the fumes into which it is reſolved by fire! they firſt become paralytic, and fall afterwards into a ſalivation. Their teeth drop out. Violent pains in the whole body, particularly in the bones, and at length death ſucceed. It may be proper to obſerve, that the Spaniſh phyſicians treat theſe patients in a different method from that purſued among us and in other countries. They expoſe them frequently for a conſiderable length of time to the open air, and give internally nothing but abſorbents.

Quickſilver is employed medicinally, in a great variety of forms; in its crude ſtate; diſſolved in different menſtrua; ſublimed with them; precipitated from them. Crude Quickſilver is uſed either by itſelf, or in compoſition with other ſubſtances. By itſelf, in a large quantity, for forcing open inteſtinal obſtructions: combined with Sulphur, into *æthiops mineral*; with powdered Antimony into an *antimonial*

Mercury.

antimonial æthiops; with different unctuous matters into *ointments* and *plaſters* both for venereal complaints and cutaneous inſects; with gums and gummy reſins into *venereal pills.* The beſt method of making the æthiops mineral is, to put the flowers of Sulphur into an iron mortar over the fire, till they begin to melt; then to remove the mortar from the fire, and ſqueeze in the Mercury through leather; and grind them well together with a warm iron peſtle. By this method they will unite more eaſily, and more perfectly than by trituration without heat.—Some take Quickſilver, powdered Antimony, Gum guaiacum, and make them into a maſs with extract of liquorice. Du Moulin, an Engliſh phyſician, abſtained from all the mercurial preparations made with Salts, and uſed only the following pills: Two ounces of Quickſilver were killed with three ounces of Venice Turpentine, then mixed with powdered Aloes, Scammony and Colocynth, of each two ounces, and a drachm of Oil of Cloves; and the whole made into a maſs with a proper quantity of Syrup of Buckthorn. Some grind the Quickſilver for a length of time with Sugar, and diſſolve it in water. Some boil Quickſilver alone in water, and thus obtain a medicine againſt worms. If the diſtilled waters of St. John's-wort, Meadow-ſweet, or Graſs-roots be made uſe of, the liquor is called *aqua hermetica.* The Mercury, by this treatment, does not appear to loſe any thing of its weight; but the water is found to have different effects from thoſe of plain water.

Chemical preparations.

The chemical preparations of Mercury are very numerous, and moſt of them unſafe or unneceſſary. Frederic Hoffman the elder juſtly obſerves, that he who has two good preparations of Mercury needs no more: and in effect, if we have but good *Mercurius dulcis* and *Cinnabar* for internal uſe, and corroſive Sublimate and red Precipitate for external, all others are ſuperfluous. Helmont alledges, that ſo long as Quickſilver can be revived, it is no ſafe medicine; but if this was true, no mercurial medicine could be ſafe.

MERCURY. ſafe. Mercury eludes all our attempts to analyſe or deſtroy it: whatever ſubſtances it is combined with, whatever operations it is ſubmitted to, it ſtill remains Mercury: we can transform it into a variety of ſhapes, but the bare action of heat, or the ſeparation of the ſubſtances joined to it, conſtantly reſtores it again to its own. Thoſe who affirm Mercury to have been, in certain operations, irreducibly deſtroyed, ſeem to have been miſled by an opinion, ſtill too common, that the ſeveral ſubſtances employed in making a preparation, are retained in the product. How many ſtill believe, that Aqua fortis, diſtilled from a mixture of Vitriol and Nitre, contains the vitriolic as well as the nitrous acid? that corroſive Sublimate, made with Vitriol, Nitre, and Sea-ſalt, contains the acids of the two firſt as well as the laſt? though it is certain, that the vitriolic acid in the one caſe, and both the vitriolic and nitrous in the other, remain at the bottom of the diſtilling or ſubliming veſſel. In like manner, Butter of Antimony has been ſuppoſed to contain the Mercury made uſe of in making it, and a Precipitate from the Butter has been diſtinguiſhed by the name of *Mercurius vitæ*: no Mercury is indeed reducible from theſe preparations, but if we examine the matter left in the retort, all the Mercury employed will be found there.

Solution. Solution of Mercury is commonly made in Spirit of Nitre or Aqua fortis: a quantity of the acid, more or leſs in proportion to its ſtrength, is poured upon the Quickſilver, and a gentle warmth applied till the whole of the Mercury is diſſolved. If the ſolution is very ſtrong of the Mercury, a part will cryſtallize upon the removal of the heat. Both the ſolution and the cryſtals are employed for other preparations.—— Mercury is diſſolved alſo in Oil of Vitriol; but for this purpoſe a conſiderable heat is required. Boerhaave calls this ſolution the *ignis gehennæ* or *infernalis* of Paracelſus; and imagines, that, when concentrated, it is the *aurum horizontale* of Helmont. If the liquor be abſtracted to dryneſs, a white maſs remains,

mains, which, on the affuſion of water, aſſumes a fine yellow colour, and, when duly edulcorated, is called *turpethum minerale*, or *mercurius præcipitatus flavus* (*m*).

Corroſive Sublimate.

The mercurial Sublimates are of two kinds; thoſe made with the acid of common Salt, and thoſe with Sulphur. To the former belong corroſive Sublimate, Mercurius dulcis, and the mercurial Panacea; the firſt of which is the baſis of the other two.——Corroſive Sublimate is no other than cryſtals of Mercury made with the concentrated marine acid, by means of ſublimation; ſome other ſubſtances being added, to facilitate the union of that acid with the Mercury. For combining Quickſilver with the acid of Sea-ſalt, it is neceſſary, that either the Mercury itſelf be previouſly diſſolved in the nitrous or vitriolic acids, in which caſe the marine will attract it from both; or that the marine acid be united with ſome fixt body, that

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(*m*) *Menſtrua of Mercury.*] Aqua fortis, of ſuch a degree of ſtrength as to diſſolve half its weight of Silver, diſſolves with eaſe above equal its weight of Quickſilver into a limpid liquor, intenſely corroſive. The ſolution inſpiſſated, or the cryſtals, aſſume, on being moderately calcined, a ſparkling red colour.——Oil of Vitriol, boiled upon Mercury to dryneſs, corrodes about an equal weight or more, into a ſaline maſs partially ſoluble in water. Kunckel obſerves, that by pouring on this white maſs a very little water at a time, ſo as not to turn it yellow, nearly the whole will be diſſolved. A total ſolution may likewiſe be obtained by repeating the coction in freſh Oil of Vitriol.——The marine acid does not act upon Mercury, unleſs highly concentrated and reſolved into fume; in which ſtate it corrodes a large proportion into a colourleſs cryſtalline maſs, which, according to the quantity of the acid, proves either pellucid, diſſoluble in water, and extremely cauſtic; or opake, indiſſoluble, and inſipid.——It has the greateſt affinity with the marine acid, and the leaſt with the nitrous. Silver is the only metallic body beſides, which is precipitated from the nitrous by the vitriolic, and from the vitriolic by the marine: and hence Mercury may, by this means, be effectually purified from admixtures of all other metals, though the proceſs is too operoſe for common uſes.——Alcaline Salts precipitate Mercury from all acids. Fixed alcalies, calcined with animal coals, if added in a larger quantity than is ſufficient for the precipitation, rediſſolve what they had before thrown down: volatile alcalies have no ſuch effect.——Vegetable acids do not act in the leaſt upon Mercury in its metallic ſtate; but ſparingly diſſolve it when reduced by fire into a powdery form, and when precipitated by alcalies from the mineral acids.——It is ſaid that, when triturated with Sugar and a ſmall proportion of eſſential Oil, it diſſolves in water; and that it gives a violet tincture to pure eſſential Oils, particularly that of Juniper-berries.

MERCURY. that may render it capable of bearing a conſiderable heat, as it naturally is in common Salt. If Mercury and common Salt were mixed together, and expoſed to the fire, the Mercury would diſtill by itſelf; but if the nitrous or vitriolic acids are added, theſe extricate the marine, which now corrodes the Mercury, and ariſes along with it in form of a white cryſtalline maſs. There are many different methods of preparing this Sublimate, as (1.) from Mercury, common Salt, Nitre, and Vitriol; (2.) from Mercury, common Salt, and Vitriol; (3.) from Mercury, common Salt, and Spirit of Nitre; (4.) from ſolution of Mercury in Aqua fortis, and common Salt; (5.) from ſolution of Mercury in Aqua fortis, and Spirit of Salt, or from the white Precipitate; (6.) from Mercury, common Salt, Nitre, and Oil of Vitriol; (7.) from edulcorated Turpeth mineral and common Salt; (8.) from red Precipitate, common Salt, and Oil of Vitriol; (9.) from edulcorated Turpeth mineral and Spirit of Salt; (10.) from Mercury, Sal ammoniac, and Oil of Vitriol, *&c.* The Sublimates obtained from all theſe mixtures may be taken indiſcriminately for any common uſes; though, in ſome of the nicer experiments, conſiderable differences are obſerved among them, eſpecially betwixt thoſe made with or without Nitre or its acid, and more particularly where the ſublimation is repeated with this or that addition.

The common method of making ſublimate at Venice, London, and Amſterdam, where ſeveral hundred weight are ſublimed at once in eight large glaſſes placed in one furnace, is, according to Tachenius's account, as follows: two hundred and eighty pounds of Quickſilver, four hundred pounds of Vitriol calcined to redneſs, two hundred pounds of Nitre, the ſame quantity of common Salt, and fifty pounds of the Caput Mortuum remaining after a former ſublimation, or, in want of this, of the Caput Mortuum of Aqua fortis, making, in all, eleven hundred and thirty pounds, are well ground and mixed together, and ſet to ſublime in proper glaſſes placed on warm aſhes: the fire is increaſed by degrees, and continued for five days and nights. In the making ſuch large quantities ſome little precautions are neceſſary, which thoſe conſtantly employed herein are beſt acquainted with; the principal are, the due mixture of the ingredients, which in ſome places is performed in the ſame manner as that of the ingredients for gunpowder; that a helm and receiver be adapted to the ſubliming glaſs, to ſave a little ſpirit which ariſes; that the fire be not raiſed too haſtily; that, when the Sublimate begins to form, the aſhes be removed from the ſides of the glaſs, or the glaſs cautiouſly lifted up a little from the aſhes; and that the elaboratory have a good chimney, by which the noxious fumes may freely paſs off. The quantities above-mentioned yield commonly three hundred and ſixty pounds of Sublimate, the two hundred and eighty pounds of Mercury gaining eighty from the acid: ſo that Sublimate conſiſts of about ſeven parts of Quickſilver, and two of marine acid. The makers of Sublimate in France, as I have obſerved in my travels in that kingdom, employ in one operation but twenty pounds of Mercury: they diſſolve the Mercury in Aqua fortis, evaporate the ſolution to dryneſs, mix with the dry matter twenty pounds of decrepitated Sea-ſalt and ſixty pounds of calcined Vitriol; and then proceed to ſublimation.

This preparation is violently corroſive, and poiſonous in a high degree to all animals. Solutions of it in water are employed, externally, for venereal and other foul ulcers. It is mixed with Antimony for making the antimonial Butter and Cinnabar, with Tin for the *Spiritus fumans caſſii*, &c. It is uſed alſo in ſome mechanic buſineſſes, particularly by the goldſmiths. Injected on ſome ſorts of brittle Gold in fuſion, it conſumes the impurities, and renders the metal malleable: ſee page 60. Some have affirmed, that Sublimate is often adulterated with Arſenic; and propoſed its turning black with alcaline Lixivia as a means of diſcovering the abuſe. But this adulteration is abſolutely impracticable, Arſenic being incapable of ariſing in ſublimation along with Mercury ſublimate. See Arſenic. If Sublimate indeed was ſold in Powder, the adulteration might be practiſed; but we may be always certain that the cryſtalline cakes have ſuffered no ſuch abuſe. With regard to the turning black with alcalies, it is ſo far from being a mark of Arſenic, that the beſt and pureſt Mercurius dulcis changes to a blackiſh grey colour both with fixt and volatile alcalies.

Mercurius dulcis.

Mercurius dulcis, called alſo *calomelas*, *manna metallorum*, *panchymagogum minerale*, *aquila alba*, and *draco mitigatus*, is a combination of corroſive Sublimate with freſh Mercury; or, more properly, it is a combination of the marine acid with as much Mercury as that acid is capable of corroding or uniting with; whilſt the corroſive Sublimate is a combination of Mercury with as much acid as it is capable of abſorbing. The *Mercurius dulcis* is ſometimes called *Mercurius ſublimatus dulcis*; but the title *ſublimatus* is better omitted, leſt the foregoing corroſive Sublimate ſhould chance to be confounded with the mild one; a miſtake which once actually happened, and which coſt the patient his life: the perſon who made up the preſcription pleaded in excuſe, that he knew of but one *Mercurius ſublimatus*, and did not think it ſafe to taſte whether it was ſweet or not.

In making *Mercurius dulcis*, the principal point is, to take crude Quickſilver enough to fully ſatiate the acid of the corroſive Sublimate. Some are accuſtomed to employ an under proportion of Quickſilver, with a view to render the preparation of a fine white colour and cryſtalline appearance: but theſe qualities, far from being of any advantage to it, or any marks of its goodneſs, denote rather that it continues in ſome degree corroſive: it is not the colour or cryſtalline form we are to regard; if it is clean, and perfectly inſipid, it is a good *Mercurius dulcis*. The Mercury ſhould be taken in equal quantity to the

Sublimate, or at leaſt three parts of Mercury to four of Sublimate; the ingredients thoroughly mixed together in a glaſs or ſtone mortar; then poured through a long funnel into a glaſs body, and ſublimed. All the matter which ariſes is to be reduced again into powder, and ſublimed a ſecond time in a freſh matras. The managements to be obſerved in the proceſs are, to ſet the glaſs pretty deep in the ſand; not to raiſe the fire too haſtily at firſt; and as ſoon as the ſuperfluous Quickſilver has ariſen, to remove part of the ſand all round the ſides. The ſublimation may be repeated three or four times, or oftener, but this nowiſe contributes to the perfection of the medicine: if there is Mercury enough, a good *Mercurius dulcis* may be made by one ſublimation; and if there is not, no number of ſublimations will ſupply the deficiency. *Mercurius dulcis* might be made even by one ſingle operation, from the ingredients which corroſive Sublimate is prepared from, by taking the Mercury in a ſufficiently large quantity. Some, after having, by two ſublimations, obtained a duly dulcified Sublimate, have ſublimed it a third time from a little common Salt and Caput Mortuum of Vitriol: this renders it cryſtalline, but at the ſame time makes it corroſive again by ſupplying freſh acid.

Mercurial Panacea.

The mercurial Panacea is a Mercurius dulcis, ſublimed eight or nine times or oftener, in freſh glaſſes, then digeſted in Balneo with rectified Spirit of Wine for a fortnight, and afterwards dried. There is alſo a black Mercurial Panacea, or a violet-coloured Mercury ſublimate, prepared from Mercury, Sal ammoniac, and Sulphur, by repeated ſublimations; but it is not in uſe. It is pretty extraordinary, that two volatile ſubſtances, often ſublimed together, ſhould fix one another: that corroſive Sublimate is thus fixed by Sal ammoniac, ſo as no longer to ſublime, appears a paradox, but is a fact.

Cinnabar of Antimony.

There are two mercurial Sublimates, made with Sulphur, not diſtinguiſhed however by the name of Sublimates, but of Cinnabars, factitious and antimonial.

nial. Both Cinnabars conſiſt wholly of Mercury and Sulphur, and differ only in the manner of combining them together. For the factitious Cinnabar, the Mercury and Sulphur are both employed in their pure ſtate; but for the Cinnabar of Antimony, the Quickſilver is previouſly united with marine acid into corroſive Sublimate, and the Sulphur is united with Regulus of Antimony into crude Antimony. The uſe of taking the ingredients ſo combined does not regard the improvement of the Cinnabar, but the obtaining of another preparation at the ſame time: the acid of the Sublimate forſakes the Mercury, and corrodes the antimonial Regulus; and theſe two, diſtilling together, form, what is called, Butter of Antimony: then follow the Mercury and Sulphur combined into Cinnabar. The antimonial Cinnabar is commonly of a worſe colour than the factitious, inclining to blackiſh, from the proportion of Sulphur being ſomewhat larger: when its colour turns out the beſt, it is not at all ſuperior to the other.

Factitious Cinnabar.

Factitious Cinnabar, called ſimply Cinnabar or Vermilion, is no where prepared in the way of trade but in Holland: the Dutch have not themſelves one grain of either of the ingredients, but procure them, with ſundry others, from us [in Germany]; and then laugh at our ſimplicity in giving up to them ſuch profitable manufactures.——To one part of Sulphur they take from ſix to eight parts of Quickſilver; and having melted the Sulphur, ſtir in the Mercury, and mix them thoroughly together: this mixture is made in the quantity of an hundred weight at a time. For ſubliming veſſels, they uſe large, oblong, coated glaſs, or earthen jars nearly of the ſame width from end to end: theſe are hung in a furnace by a ſtrong rim of Iron. When the matter is put in, the mouth of the veſſel is covered, the fire increaſed by degrees, and continued for ſeveral hours, till all the Cinnabar has ſublimed; care being taken to introduce at times an Iron rod to keep the middle clear, otherwiſe the Cinnabar concreting there and ſtopping up the paſſage, would infallibly burſt the veſſels. I remember an accident of this kind in the royal garden at Paris: Mr. Boulduc had contrived a method by which he ſaid Cinnabar might be ſublimed more expeditiouſly than in the common way; but the blocking up of the neck of the veſſel not being provided againſt, the whole flew in pieces at once, with a horrible exploſion (*n*).

The Cinnabar ſublimes in large cakes, of a dark red colour, and a needled or ſtriated texture like Antimony. The Dutch grind it into powder in mills made for that uſe; which no ſtranger is permitted to ſee: though I have been ſeveral times in Holland, and ſpared no pains or expences, I have never been able to obtain any farther information about this part of the manufacture, than that Urine or Brandy are added in the grinding. The painters find, that the Vermilion ground by the Dutch dries ſooner than any other, and hence ſuſpect that ſome foreign matter is mixed with it; pure Vermilion drying exceeding ſlowly: in ſome Parcels white or red Lead are ſaid to have been diſcovered, though ſuch as I examined gave no marks of either of theſe, only a ſmall portion of brown earth being left upon reſubliming it. However this may be, we ſhould always chuſe, for medicinal uſe at leaſt, Cinnabar in the cake, as being leſs liable to adulteration than that which is ground into powder. Its total evaporation in the fire may be looked upon as a ſure mark of its purity.

Mercurial Precipitates.

There are ſundry mercurial Precipitates, properly ſo called, as being prepared by precipitating Mercury from its ſolutions in acids by means of certain additions.

(*n*) *Cinnabar.*] Hoffman gives a curious method of making Cinnabar without ſublimation; by ſhaking or digeſting a little Mercury with volatile tincture of Sulphur: the Mercury readily imbibes the Sulphur from the volatile Spirit, and forms with it a deep red powder, not inferior in colour to the Cinnabar prepared in the common manner. I have varied the experiment, by employing, inſtead of the volatile tincture, the more eaſily parable ſolutions of Sulphur made with fixt alcalies, and with Quick-lime; and with theſe alſo I have obtained a perfect Cinnabar, of a brighter or darker colour according to the proportion of Sulphur.

additions. Sea-ſalt, Sal ammoniac, or Spirit of Salt, added to a ſolution of Mercury in Aqua fortis, throw down a white Precipitate, differing little from corroſive Sublimate; the Mercury forſaking the nitrous acid in which it was diſſolved, and uniting with the marine into a concrete leſs diſſoluble. Spirit of Sal ammoniac, added to the ſame ſolution, throws down a white Precipitate much leſs corroſive. Corroſive Sublimate, diſſolved in water, yields alſo with volatile alcalies a white Precipitate mild like the preceding. Solution of Sublimate, mixed with a ſolution of crude Sal ammoniac, depoſites upon adding fixt alcalies a like white Precipitate; but if fixed alcalies are added to a ſolution of Sublimate alone, the Precipitate is of an orange colour. A ſolution of Mercury in Aqua fortis yields, like the ſolution of Sublimate, an orange coloured Precipitate both with fixed alcaline Salts and with Lime-water. A Precipitate made from it with warm urine is of a reddiſh or roſe colour.

Red Precipitate.

Solutions of Mercury inſpiſſated are called alſo, improperly, Precipitates. Red Precipitate is prepared by evaporating a ſolution of Mercury made in Aqua fortis, and gently calcining the remaining dry matter, till it acquires a ſparkling yellowiſh-red colour. The greateſt quantities of this preparation are made by the manufacturers of Sublimate, who ſave the expence of Aqua fortis by employing the ſpirit which ariſes in that operation. If the red Precipitate be reduced into fine powder, and freſh parcels of rectified Spirit of Wine diſtilled off from it or burnt upon it, its corroſiveneſs is conſiderably abated; a part of the acid being diſſipated in the burning, or ariſing with the ſpirit in diſtillation, ſo as to change it into a *Spiritus nitri dulcis*. The preparation is now called *Mercurius præcipitatus corollatus*, or *arcanum corallinum*. In England the red Precipitate is dulcified alſo by grinding it on a levigating ſtone with a few drops of Oil of Tartar per deliquium, and afterwards burning rectified ſpirit upon it. Thus prepared,

pared, it is called *pulvis principis*. In ſome places a green precipitate is made from ſolution of Mercury in Aqua fortis, by adding a ſolution of Verdegris. This is named *lacerta viridis*, and *antivenereum mercuriale*. The Copper renders it too dangerous for any internal uſe. — The yellow Precipitate, called *turpeth mineral*, is prepared by boiling Quickſilver with an equal weight or more of Oil of Vitriol in a retort, and continuing the fire till the matter has become thoroughly dry, and the veſſel red hot. Warm water poured on the white maſs which remains, turns it inſtantly yellow; after which the matter is to be waſhed with freſh parcels of water, till the liquor comes off perfectly inſipid. If Oil of Vitriol be ſeveral times drawn over from Mercury, the maſs proves conſiderably fixed in the fire. It melts without evaporating, and whilſt in fuſion looks like blood.

Turpeth mineral.

The *mercurius precipitatus per ſe* is properly a calx of Mercury. It is prepared by digeſting the Mercury for a length of time, ſeveral weeks, or even months, in a flat-bottomed glaſs, ſlightly ſtopt or covered with paper to keep out duſt, but by no means luted or hermetically ſealed as ſome direct, a communication with the external air being neceſſary to the ſucceſs of the proceſs. No more Quickſilver ſhould be put into one glaſs than is ſufficient to cover its bottom. The veſſel ſhould be placed in ſand, in ſome furnace where a conſtant heat is to be kept up, and the ſand raiſed round the glaſs a very little higher than the ſurface of the Mercury within. The degree of heat is one of the principal points; if too ſtrong, the Mercury will be diſſipated, and if too weak, it will not undergo the intended change. It ſhould be gentle at firſt, and increaſed with caution. When a quantity of calx or red powder has thus once been obtained, the admixture of this with freſh Mercury remarkably promotes its calcination. From this circumſtance the philoſophers by fire have been led into many different ſpeculations, which in general have

Calx of Mercury per ſe.

MERCURY.

have but little foundation. The change which the Mercury undergoes is not near ſo great as they have imagined. On a bare increaſe of the heat, it puts off its diſguiſe, and reſumes its original running form. Mercury may be changed into powder by bare agitation in a cloſe veſſel. This powder differs from that obtained by fire, in being of a grey or black colour. See page 134.

Mercurial waters.

Sundry mercurial waters, and oils as they are called, are employed by the ſurgeons, almoſt every one having a preparation of this kind of his own. They are all only diluted ſolutions of Mercury; having for their baſis either ſolution of corroſive Sublimate, or a ſolution of Quickſilver in Aqua fortis. A drachm of Sublimate, diſſolved in a pint of Plantane water, makes the *aqua divina* of Fernelius.

Amalgamation.

Amalgamation, or the ſolution of metals in Mercury, is ranked as one of the chemical operations. In ſome caſes it ſeems to depend as much upon the Mercury being divided by the metalline powder, as on its power of diſſolving the metal as a menſtruum. For obtaining an amalgam or a kind of paſte of Quickſilver and metals, the metal ſhould previouſly be reduced into ſmall parts, either by mechanic operations, as granulation, filing, &c. or by ſolution in acids and precipitation. The precipitation ſhould be made, not with Salts, for the calces thrown down by Salts will not unite with Mercury; but with ſome other metal. Thus Silver is to be precipitated by Copper, Copper by Iron, &c. Heat promotes amalgamation. By its aſſiſtance we may obtain amalgams of ſome metallic bodies that cannot be amalgamated without it. See page 95.

Coagulated Mercury.

Much has been talked of ſolid or coagulated Mercury; but all the preparations of this kind, if they have any Mercury in them, are no other than hard amalgams. When melted Lead or Tin are juſt becoming conſiſtent, a ſtick is thruſt into the metal, and the hole filled with Quickſilver. By the time the whole is grown cold, the Mercury is found ſolid and crumbly, the heat having promoted the union of the metal with it. Maurice Hoffman, in the acts of the Altdorff elaboratory, gives a proceſs for reducing the Mercury ſo coagulated to a ſtate of malleability, by repeatedly melting and quenching it in Linſeed-oil. A malleable metal is thus really obtained, which may be formed, as he promiſes, into rings; but it is not Mercury. All the Mercury is diſſipated in the fuſions, and nothing is left but the Lead or Tin. Still more ridiculous are thoſe, who, melting an amalgam of Copper along with Tutty, imagine the Braſs that reſults to be a production of the Mercury.

A diaphoretic fixt Mercury has been a grand object of purſuit among the chemiſts. I have met with many pretenders to ſuch an arcanum, but have never yet found any truth in their pretences; ignorance of the principles of genuine chemiſtry, and of the properties of the bodies which they worked upon, having led them to believe, that when they had loſt their Mercury, they had fixed it. One made his fixt Mercury, by diſſolving two ounces of Quickſilver in Aqua fortis, adding by degrees one ounce of Regulus of Antimony, and then mixing a quantity of brine of Sea-ſalt. The matter being now exſiccated, he proceeded to the fixation, that is, the diſſipation, of the Mercury, by deflagrating the mixture with Nitre.

Alkaheſt.

But the moſt extraordinary of all the preparations, which the alchemiſts have pretended to make from Mercury, is the alkaheſt or univerſal menſtruum. Kunckel has ſhewn the abſurdity of ſuppoſing them poſſeſſed of ſuch a menſtruum, by a ſimple queſtion, "If it will diſſolve every thing, what veſſel can it "be kept in?"

Mineral hiſtory.

Quickſilver is found in the earth, ſometimes in its running form, but much more commonly in that of an ore. The native running Mercury, called Virgin, has been preferred by ſome to that which is extracted from the ore and purified by art; but no experiment affords any foundation for ſuch a preference.

The

MERCURY.

The ores are of three kinds, (1) fine red ones, called native Cinnabar, differing from the factitious Cinnabar only in having ſome earthy, ſtony, or other heterogeneous matters intermixed, (2) ſtony ores, and (3) clayie or loamy earths. The two laſt ſorts are much poorer in Mercury than the firſt. They contain more Sulphur than is requiſite for forming a red cinnabarine compound, and appear commonly of a blackiſh or greyiſh-black colour, without ſo much as a ſpeck or a vein of red.

Mines of Quickſilver are extremely rare (*o*). The only conſiderable ones known are in ſome parts of the imperial hereditary dominions, and in Spain; particularly at Friuli and Iſtria in Carinthia; and at Almaden de la Sierra Morena in the province of Eſtremadura. The ores in the imperial dominions are chiefly of the cinnabarine kind; the Spaniſh, poorer and more earthy. Spain however produces as much Quickſilver as Fruili, or rather more. At Almaden, in the year 1717, there were twenty-five thouſand quintals or Spaniſh hundred weights of Quickſilver, which amount to above three millions of pounds of our weight. From thence are ſent yearly to Mexico, fleets laden with Quickſilver, for the amalgamation and extraction of Gold and Silver from the rich minerals of that country. The exportation either of Mercury or Cinnabar to other places, is prohibited. The mines of Friuli have been obſerved to afford 695,334 pounds of Quickſilver in three years. All the imperial Quickſilver is brought to Holland, the Dutch having entered into a contract with the Emperor for that purpoſe.

It may be proper to obſerve, that Mercury is never found in the mines of any other metals; nor any other metals in the mines of Mercury; except that ſometimes

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(*o*) *Mines of Quickſilver rare.*] According to Hoffman's computation, the annual produce of Gold from mines is fifty times greater than that of Quickſilver. Cramer ſuſpects he means only five times; and that Quickſilver occurs in the earth more frequently than we are aware of; this volatile ſemimetal being diſſipated in the common proceſſes by which ores are worked or aſſayed.

ſometimes a mineral containing a little Gold or Silver ſhall be met with among mercurial ores, and even this is an exceeding great rarity. This obſervation ſeems to ſufficiently refute the opinion of thoſe who hold Mercury to be an hypoſtatic principle or ingredient in all metals. For if metals were, and continued to be, produced from Mercury, we certainly ſhould, ſometimes at leaſt, diſcover one where the other is.

Lemery, Pomet, and others, lay down ſome external marks for diſtinguiſhing thoſe places in which there are mines of Quickſilver; namely, thick vapours, like clouds, ariſing in the months of April and May; the plants being much larger and greener than in other places; the trees ſeldom bearing flowers or fruit, and more ſlowly putting forth their leaves. But theſe marks are far from being certain. They are not obſerved in all places where there is Quickſilver, and they are obſerved where there is none. In the Hartz-foreſt we ſee abundance of thoſe cloudy exhalations, though not a grain of Mercury is found there.

Extraction from its ores.

The method of extracting Quickſilver from its ores differs according to the ſubſtances naturally joined to it. For the imperial cinnabarine ores, certain additions are employed to abſorb the Sulphur, as filings of Iron. Or the ore is diſtilled *per deſcenſum* in perforated Iron pots. The Spaniſh ores require no addition, nor any iron veſſels, theſe naturally containing a calcareous earth ſufficient to imbibe the Sulphur. The ore being thrown in at one end of a furnace, the Mercury is extricated in fume from all its natural admixtures, and, after paſſing through a number of horizontal aludels, condenſes in a reſervoir at the further extremity. In ſome places the more impure ſtony ores are ſtamped, and the lighter matters waſhed off from them; after which the more ponderous and pure part is diſtilled either by itſelf or with additions according to its quality. An account of the Spaniſh Quickſilver furnaces may be ſeen in the French Memoirs for the year 1719.

The

CINNABAR.

Its natural hiſtory.

The finer coloured cinnabarine ores are never worked for Mercury, but employed as Cinnabar; and have by many been injudiciouſly preferred to the more pure factitious Cinnabar. We ſeldom meet with any native Cinnabar that has not a viſible admixture of earthy or ſtony matter, nor with two pieces that perfectly agree.

Maſſes of native Cinnabar are found in Hungary, Tranſylvania, Carinthia, Bohemia, the Palatinate, France, Spain, ſometimes in Sweden, and as is ſaid in the Eaſt-Indies, particularly Japan, but greateſt part of what is ſold under the name of Japan Cinnabar, is manufactured in Holland. In the ſhops, three principal ſorts are diſtinguiſhed, (1.) Cinnabar in maſſes, ſome of which weigh one, two, ſix ounces, and more. (2.) Cinnabar in grains, prepared by breaking the coarſer maſſes, and picking out the bits of Cinnabar from the ſtony matter intermixed. (3.) Waſhed Cinnabar, prepared from ſuch maſſes as are ſtill fouler, by reducing them to powder, and waſhing off their lighter impurities. The firſt ſort is accounted the beſt, and the laſt the worſt. Many have been particularly fond of the Hungarian Cinnabar, ſuppoſing it be impregnated with Gold, becauſe in Hungary there are mines of Gold. So far has this ridiculous conceit prevailed, that not only the minerals, the Cinnabar, the Antimony, the Copper, the Vitriol, but the very vine-trees of Hungary, have been imagined to participate of that metal.

Chemical examination.

Native Cinnabar ſhould never be employed for any medicinal uſe without purification; and the only method of purifying it effectually is ſublimation; the ablution, by ſome directed, being by no means ſufficient. I have never met with any that did not leave on ſublimation a grey aſh or ſand, amounting, in different parcels, to one ninth, one eighth, one ſeventh, one ſixth, and one fifth of Cinnabar employed. Sixteen ounces of waſhed Cinnabar left above two ounces of fixt matter. Of the part which ſublimed, only about ten ounces were pure compact

Cinnabar, the reſt being ſpongy, and not ſo clean. By repetitions of the ſublimation, the whole became purer and finer coloured. The reſiduum imparted to Aqua regia a yellow colour like that of a ſolution of Gold; and Spirit of Sal ammoniac precipitated from this tincture a calx which looked like Aurum fulminans. It did not however fulminate, nor give any other marks of Gold than its colour. What particular ſubſtance this ſoluble part of the reſiduum was, I did not examine; but it certainly was not Gold, for Aqua fortis diſſolved it as well as Aqua regia.

Cinnabar.

Some add a little calcareous earth in the ſublimation of Cinnabar; to abſorb a portion of its Sulphur, and thus improve its colour. It is an over-proportion of Sulphur that makes the colour blackiſh, and not, as ſome have pretended, too ſtrong a fire; for ſtrong fire does no injury to Cinnabar.

The proportions of Mercury and Sulphur are different in different Cinnabars. The ordinary ſorts, purified by ſublimation, contain commonly four parts of Mercury to one of Sulphur. The finer have more Mercury. It is obſervable, that though Oil of Vitriol forms with Mercury a lively yellow concrete, Turpeth mineral; and with the inflammable principle, a yellow Sulphur; and though this Sulphur forms with Mercury a beautiful red Cinnabar, yet Oil of Vitriol totally deſtroys this red colour, changing the Cinnabar white as milk.

II. BISMUTH.

Bismuth.

Its general properties,

BISMUTH, or Tin-glaſs, is a ſparkling white ſemimetal, very ponderous, conſiderably hard and ſonorous, extremely brittle, without any degree of malleability, falling in pieces under the hammer, and reducible by triture into fine powder. When broke, the ſurface of the fracture appears compoſed of bright plates or flakes, larger than thoſe of the other ſemimetals. In its external appearance, it has a great reſemblance to Regulus of Antimony and Zinc,

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Zinc, differing little otherwiſe than in the largeneſs of the plates, and in its contracting a yellowiſh caſt on the ſurface expoſed to the air. In its intrinſic properties, it is extremely different; melting far more eaſily, not evaporating ſo readily, being differently acted upon by acids, producing different effects upon other metallic bodies, &c.

examined by fire,

Biſmuth melts in the fire long before it grows red hot, conſiderably ſooner even than Lead. Kept in fuſion and ſtirred, it ſoon calcines; gaining at the ſame time an increaſe in its weight, of near half an ounce upon a pound. The calx melts, upon raiſing the fire a little, into a browniſh or yellowiſh glaſs; which promotes the vitrification of earths and the refractory metallic calces more powerfully, and corrodes and ſinks through the common crucibles more readily than glaſs of Lead itſelf. If Biſmuth be mixed with Gold or Silver, a heat that is but juſt ſufficient to melt the mixture, will preſently vitrify a part of the Biſmuth, which then having no action on thoſe perfect metals, ſeparates and glazes the crucible all round (*p*).

Calx of Biſmuth, long reverberated, does not, as ſome pretend, become red like the calces of Lead. It ſcarcely retains even the form of a calx, a part of the Biſmuth being revived into its metallic appearance by the flame. None of the deſtructible metallic bodies is ſo eaſy of revival as this ſemimetal. If the veſſel is covered, and all inflammable matters excluded, vitrification is the only change that enſues.

by the nitrous acid,

The nitrous acid diſſolves Biſmuth with great efferveſcence, and a copious diſcharge of yellow corroſive

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(*p*) *Biſmuth.*] This ſemimetal approaches in ſpecific gravity to Silver, being nearly ten times heavier than an equal bulk of water. It melts a little later than tin, and ſeems to flow the thinneſt of all metallic ſubſtances. When in fuſion it occupies leſs volume than in its ſolid ſtate: a property peculiar to Iron among the metals, and Biſmuth among the ſemimetals. It emits fumes in the fire ſo long as it preſerves its metallic form. When calcined or vitrified, it proves perfectly fixed.

roſive fumes. The ſolution, if the Biſmuth has not been too haſtily added to the acid, proves colourleſs and tranſparent (q). Diluted with a large quantity of water, it becomes milky, and depoſites, on ſtanding, a fine white Precipitate or Magiſtery; which edulcorated by repeated affuſions of water, is employed as a coſmetic, both in waſhes and pomatums, under the name of Spaniſh or pearl white.

Magiſtery of Biſmuth

There are ſundry variations in preparing this Magiſtery. Some take Aqua regia for the menſtruum; and for the precipitant, a ſolution of Sea-ſalt, alcalies, Spirit of Wine, *&c.* Some mix with the ſolution of Biſmuth, a ſolution of Benzoine in Spirit of Wine, and thus obtain a Magiſtery compoſed of calx of Biſmuth and Benzoine. Others add a ſolution of Chalk to the metalline ſolution, and precipitate both together with alcalies. I have made trial with a good number of different precipitants, and found, that with common fixt Alcali and cauſtic Alcali, with watery and vinous alcaline ſpirits, the Magiſtery was white, and in conſiderable quantity; the liquor after the precipitation with volatile ſpirits, appearing blue. That Oil of Vitriol threw down a white Precipitate very copiouſly; but that with Spirit of Vitriol, Spirit of Salt, and weak Spirit of Nitre, the Precipitate was in very ſmall quantity, in colour white like the foregoing; and that diſtilled Vinegar made no precipitation at all. That common rectified Spirit of Wine and tartarized Spirit, common water and Lime-water, gave white Precipitates. That ſolutions of Nitre, vitriolated Tartar, Sal mirabile, Alum,

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(q) *Nitrous acid.*] Proof Aqua fortis diſſolves about half its weight of Biſmuth. If the ſolution is haſtily performed, the liquor appears greeniſh. A part of the Biſmuth cryſtallizes almoſt as faſt as it diſſolves, or at leaſt as ſoon as the heat ariſing from the action of the acid ceaſes, unleſs the menſtruum is diluted with about an equal quantity of water. —— Both fixt and volatile alcalies totally precipitate it. Volatile alcalies, added in larger quantity than is ſufficient for that effect, take it up again. The liquor generally appears greeniſh; by alternate additions of the alcaline ſpirit and of the ſolution, it becomes bluiſh or purple. Fixed alcalies, calcined with inflammable matter, likewiſe rediſſolve the Biſmuth after they have precipitated it.

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Alum, Borax, common Salt (*r*), Sal ammoniac, the combination of calcareous earth with marine acid, called fixed Sal ammoniac, and the terra foliata Tartari, all precipitated the Biſmuth white. That with a ſolution of Gold in common Aqua regia the Magiſtery proved grey; with a ſolution of the ſame metal in an Aqua regia made with Spirit of Salt, it was likewiſe grey, but in much leſs quantity; with ſolution of Copper in Aqua fortis, white, and in very ſmall quantity, the liquor continuing blue; with ſolution of Vitriol of Copper, white; with ſolution of Mercury ſublimate, white and plentiful; with ſolution of Iron in Aqua fortis, yellowiſh; with ſolution of Lead in Aqua fortis, and of Sugar of Lead, white; with ſolution of Zinc in Aqua fortis there was little Precipitate; and with ſolutions of Silver, of Tin, of Regulus of Antimony, and of Mercury, in the ſame acid, none at all. On boiling ſome powdered Biſmuth in a ſolution of green Vitriol, the liquor did not grow turbid, as it would have done by itſelf, but rather clearer and clearer. A fixt alcaline Lixivium being afterwards added, it turned white and thick; but, on ſtanding for ſome time, depoſited a greeniſh matter, which, on drying, changed to a light brown. A little of the liquor evaporated and ſet to ſhoot, yielded cryſtals, which in appearance and taſte reſembled Vitriol of Iron.

Some prepare the Magiſtery of Biſmuth, by ſubliming the powdered Biſmuth with Sal ammoniac, diſſolving the flowers in diſtilled water, and then precipitating with volatile or fixt alcali. Others add Nitre in the ſublimation, but this addition rather injures

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(*r*) *Precipitate by Sea-ſalt.*] It has been commonly ſuppoſed that Sea-ſalt, or its acid, carry down Biſmuth from its ſolution in the nitrous acid, in the ſame manner as it does Silver, Lead, and Mercury. A ſolution of Sea-ſalt will indeed precipitate all the four, but with this difference, that the precipitates of the three latter are found intimately combined with the acid of that Salt; whilſt the Precipitate of Biſmuth retains nothing of it, and was thrown down, not by the ſaline, but by the aqueous part of the liquor. Simple water precipitates it, but Sea-ſalt undiſſolved, or a ſolution of it added in ſmall quantity, does not.

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jures than improves the colour of the product. And indeed the Sublimates obtained by either method are leſs fit for making the Magiſtery than Biſmuth in ſubſtance, for the ſolution of them, whatever care is taken in the operation, will not be limpid, but green. Some, inſtead of the Magiſtery, direct a calx to be made by deflagrating the Biſmuth with Nitre, expecting that the Biſmuth will detonate like Antimony, and that the calx will reſemble that of Antimony prepared in the ſame manner. Others direct the flowers which ariſe during the deflagration, to be caught in aludels for the ſame purpoſes. But Biſmuth, though it is very readily calcined by Nitre, does not ſenſibly deflagrate with it. The flowers and the calx are not perfectly white, but yellowiſh; and the quantity of the flowers is ſmall, only two ounces having been obtained from ſixteen.

The Magiſtery of Biſmuth appears to have ſome latent corroſive quality; and when freely uſed as a fucus, not to be entirely innocent. It gradually impairs the natural complexion; and leaves, for old age, a coarſe and diſagreeable ſkin. The peruke-makers are ſaid to employ it in their pomatums for giving a whiteneſs to grey, reddiſh, yellow, or other coloured hair; and Pomet obſerves that a ſhower of rain will waſh of this adventitious whiteneſs. I have been informed alſo, that thoſe who bleach hair in England make uſe of this Magiſtery; and therefore I determined to examine by experiment its effects upon hair. Experiment ſatisfied me that the report was groundleſs; that the Magiſtery of Biſmuth does not whiten hair but darken it; that it changes the whiteſt flaxen hair firſt to a yellowiſh, then to a yellowiſh brown, afterwards to a dark brown, and at laſt to a black. The trial may be made in two ways: by boiling the hair in water along with the Magiſtery; and by applying the Magiſtery mixed with Pomatum, or hanging the hair in the ſun. The oftener this is repeated, the darker will the colour be. We may judge from hence, that this Magiſtery is leſs fit for the purpoſes of a coſmetic than it is generally ſuppoſed

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poſed to be. The Magiſtery itſelf has been commonly believed to change its colour in the ſun, and hence it is directed to be dried cautiouſly in a ſhady place; but it did not appear to have ſuffered any conſiderable alteration on being expoſed to the ſun for two months. It is apt, however, in length of time, to turn yellowiſh; and hence a large ſtock ſhould not be prepared at once.

treated with marine acid.

Spirit of Sea-ſalt, though long boiled with Biſmuth, diſſolves very little; and Aqua regia not much. The effect of the concentrated marine acid in Mercury ſublimate I was induced to try, from Mr. Boyle's account of a pearl-like ſublimate obtained from Biſmuth and that mercurial preparation. One part of Biſmuth in fine powder, and two of corroſive Sublimate, mixed together and expoſed to the fire in a retort, immediately melted into a blackiſh brown pitch-like maſs: a portion of Quickſilver diſtilled, was followed by a dark brown butter, which on cooling grew hard as a ſtone: in the retort, a little melted Biſmuth remained. On rectifying the butter a ſecond and third time ſome more running Mercury ſeparated, the butter became clearer and browner, and at the ſame time harder. On a fourth rectification, I had two kinds of butter, a white and a brown. The white being rectified twice by itſelf, an unctuous pearl-coloured matter remained each time, and the butter became ſtill whiter. The brown was then mixed with the white, and the rectification again repeated ſix times. A like pearl-coloured ſubſtance was left in every diſtillation, the quantity of butter grew leſs and leſs, and at length there was none to be ſeen. So that by this troubleſome operation I obtained the product intended by the author, though it was not properly a Sublimate, having remained in the retort after ſublimation.

Pearl-coloured powder,

Oil

(s) *Oil of Vitriol with Biſmuth.*] The vitriolic acid in ſome degree corrodes this ſemimetal, but does not perfectly diſſolve it, however concentrated or aſſiſted by heat. The roſe-coloured ſolution, mentioned by

Oil of Vitriol diſſolves Biſmuth into a roſe-coloured liquor (*s*), which on ſtanding turns browniſh; but Spirit of Vitriol has little effect. If a ſolution of Biſmuth in Aqua fortis be evaporated to one half, ſome Quickſilver and Oil of Vitriol added, the evaporation continued to dryneſs, and the dry matter ſet to ſublime; there ariſes firſt a little Quickſilver, and afterwards a perfectly white mealy Sublimate. In the bottom of the retort remains a greeniſh matter variegated, if the heat has been ſtrong, with rainbow colours. Diſtilled Vinegar diſſolves a little by ſtrong coction, and acquires from it, not, as ſome pretend, a ſweet taſte like that of ſaturnine ſolutions, but a conſiderably acerb and ſtyptic one.

with Oil of Vitriol,

Biſmuth cemented with Sulphur readily unites with it, and melts eaſier than by itſelf; but, on continuing the fire, they ſoon ſeparate again, the Biſmuth falling to the bottom, and a ſulphureous ſcoria ſwimming on the ſurface. Calx of Biſmuth likewiſe very eaſily abſorbs Sulphur, and forms with it a curious needled maſs, exactly reſembling Antimony, contracting a reddiſh tinge externally on expoſure to the air. The quantity of Sulphur imbibed is leſs than half the weight of the calx; a part of the Sulphur having ſublimed when the operation was performed, in a retort, with that proportion. Silver added to this antimoniated concrete, melts with it, in a very gentle heat, into a brittle Regulus. Gold alſo unites with it, but requires a much ſtronger fire; the compound is brittle, in appearance like an ore, with here and there ſome ſtriæ or ſhining particles. Copper melts with it, in a ſmall heat, with remarkable facility; and after they have been united, the compound continues to retain this extraordinary fuſibility. On the addition of Lead, a new combination happened: the Copper and Sulphur aroſe to the ſurface in ſcoria reſembling an ore, whilſt the Biſmuth and Lead formed a Regulus at the bottom.

with Sulphur.

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by the author, was probably obtained, not from Biſmuth itſelf, but from Biſmuth ore; the ore participating of a metallic ſubſtance of a different kind, which gives a reddiſh colour to all acids.

with different metals.

With regard to the effects of Biſmuth upon metals (*t*), (1.) Equal parts of Biſmuth and Gold melted together, formed a quite brittle Regulus, which had ſcarce any yellowiſh hue, and looked almoſt like Biſmuth itſelf; as ſoon as they began to melt, a vitreous matter appeared round the crucible. (2.) Equal parts of Biſmuth and Silver formed a white compound, leſs brittle than that with Gold. It bore the hammer a little, and ſeemed at firſt as if it was going to extend, but at laſt it cracked. The ſame ſudden vitrification was obſerved, as in the foregoing experiment. (3.) With Tin, it melts exceeding eaſily. The mixture at firſt frequently admits ſmall flames, and a part calcines. When the quantity of each was half an ounce, the loſs was five grains. If the fire is raiſed, the compound quickly calcines, like a mixture of Lead and Tin, into a yellowiſh white aſh. A ſmall portion of Biſmuth improves the brightneſs, hardneſs, and ſonorouſneſs of Tin. (4.) Copper is ſaid to be changed of a Silver colour by Biſmuth: and hence the ſemimetal has been named *marcaſita argentea*; as Zinc, from its making Copper yellow, is called *marcaſita aurea*. In my experiments there was no appearance of a Silver colour, except that when Biſmuth was in very large proportion, its whiteneſs prevailed above the redneſs of the Copper. Copper mixed with an equal weight of Biſmuth had its red colour only diluted or rendered paler, and its malleability deſtroyed. A part was changed in the fuſion, into a dark red ſcoria, amounting to a drachm

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(*t*) *Biſmuth with metals.*] Biſmuth does not mingle in fuſion with Regulus of Cobalt or Zinc. The addition of Nickel or Regulus of Antimony, renders it miſcible with the former, but not with the latter. It unites with all the others, and greatly promotes both the tenuity and facility of their fuſion. It whitens Copper and Gold, and improves the whiteneſs of ſome of the white metals. Mixed in conſiderable quantity, it renders them all brittle, and of a ſtructure, like its own, flaky or plated. Though it poſſeſſes ſeveral properties of Lead, and in certain circumſtances remarkably ſubtilizes that metal, yet in mixture they agree but ill together. On expoſing compoſitions of them to a moderate fire, a colluctation enſues, and both metals fall quickly into a calx, like a mixture of Lead and Tin.

drachm upon half and ounce of each of the ingredients. (5.) Equal parts of Biſmuth and Lead yielded a dark grey compound, which bore to bebent a little without breaking. The loſs in fuſion was two ſcruples upon half an ounce of each of the metals. (6.) Iron and Biſmuth, in the ſame proportions, emitted flames in the fire, and in a ſtrong heat united together. (7.) The ſame quantities of Regulus of Antimony and Biſmuth melted perfectly together, and loſt only fifteen grains. The mixed looked like Regulus of Antimony by itſelf. (8.) Zinc and Biſmuth did not unite at all, the Zinc flowing diſtinct upon the ſurface, and burning as it does by itſelf. (9.) Mercury forms with Biſmuth an amalgam, which readily adheres to Iron. If the Iron, coated with the amalgam, be expoſed to the fire, the Mercury exhales, and greateſt part of the Biſmuth remains fixt upon the Iron, which now looks as if it had been ſilvered. If mixtures of Biſmuth with ſome other metals, particularly Lead, be amalgamated, the Lead is found to be ſo attenuated, as to paſs with the Quickſilver through leather. On ſtanding, the Biſmuth is thrown up to the ſurface in form of a dark-coloured powder, the Lead remaining diſſolved in the Quickſilver. (10.) Equal parts of Lead, Copper, and Biſmuth, yielded a Regulus of a ſooty black colour on the upper ſurface. The loſs in fuſion was one drachm upon three half ounces of the mixture. (11.) Equal parts of Lead, Tin, and Biſmuth, formed a blackiſh ſparkling compound, reſembling the ſmall-diced ores of Lead. (12.) It is obſervable, that the ſpecific gravity of a mixture of Biſmuth and Copper is exactly the mean gravity of that of the two ingredients unmixed; but that mixtures with Iron are ſpecifically lighter than the ingredients ſeparately; and mixtures with Gold, Silver, Tin, Lead, and Regulus of Antimony, heavier.

BISMUTH.

Uſes.

Biſmuth is applied to various uſes in the chemical arts, as (1.) For making Pewter with Tin; this metal

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tal being of itſelf too ſoft for the common purpoſes of utenſils, and never being worked without ſome additional metallic matters, of which Biſmuth is one of the principal. (2.) For ſoldering Lead and Tin; a mixture of Biſmuth with theſe metals being eaſier of fuſion than either of them ſeparately. The common ſolder is compoſed of two parts of Lead, two of Tin, and one of Biſmuth (*u*.) As an ingredient in the compound metal for Printers types. Types indeed are often made, without any Biſmuth, from a mixture of one part of Copper, one of Antimony, and five of Lead; but Homberg, a celebrated German chemiſt, who ended his days in Paris, has obſerved, that the addition of Biſmuth and Tin greatly improves the compoſition: he adviſes equal parts of theſe to be melted together, and one part of this maſs to be melted with ſix of the ordinary mixture. (4.) In foils for mirrours; the common mixture for theſe purpoſes conſiſts of one part of Tin, one of Lead, two of Biſmuth, and ten of Quickſilver, amalgamated together. A particular account of the manner of preparing and foiling reflecting glaſs-balls may

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(*u*) *Fuſibility of mixtures of Biſmuth, Tin, and Lead.*] The degree of heat, in which theſe metals by themſelves, and certain mixtures of them, melt, or, when melted, begin to ſet or grow ſolid again, has been examined by thermometers. The following table exhibits nearly their proportional fuſibility, compared to the heat of boiling water and Quickſilver, according to Fahrenheit's ſcale.

600.	Quickſilver boils.
540.	*Lead melts.*
460.	*Biſmuth melts.*
410.	*Tin melts.*
390.	*Tin 8. Biſmuth 1. melt.*
330.	*Tin 2. Biſmuth 1. melt.*
	Tin 3. Lead 2. melt.
280.	*Equal parts of Tin and Biſmuth melt.*
212.	Water boils.

In theſe kinds of experiments, and indeed in all caſes where the heat is continually increaſing or decreaſing, we cannot expect any great degree of preciſion; for as the thermometer receives only ſucceſſively the heat which acts upon it, it cannot expreſs the exact heat of the body applied at any particular inſtant of time. Whilſt the inſtrument expreſſes one degree of heat, the ſurrounding matter may have acquired a conſiderably greater or ſmaller; and by the time that the thermometer has riſen or fallen to that degree, the heat of the matter may be again varied.

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may be ſeen in Boyle's treatiſe on the uſefulneſs of experimental philoſophy. (5.) In mixtures for anatomical injections, particularly of the lungs: ſome take equal parts of Biſmuth, Lead, and Tin; others add a little Quickſilver. (6). For imitating Silver on wood. The turners grind Biſmuth into a ſubtile powder, and temper it with whites of eggs: this applied on wood looks, when dry, of an aſh colour; but, on being burniſhed with a tooth, it aſſumes the appearance of duſky Silver. (7.) For imitating Silver upon Iron, as mentioned in the ninth experiment of the preceding paragraph. (8.) For purifying Gold and Silver by cupellation, ſcorification, &c. For theſe purpoſes it is preferable to Lead, as it more effectually promotes the deſtruction of the imperfect metals, and the vitrification of earths and calces (*x*). It has one great advantage above Lead in all operations of this kind, where Sulphur makes one of the ingredients; namely, its forming with that concrete an extremely fuſible maſs, whilſt Lead combined with Sulphur, proves extremely refractory.

Abuſes.

Biſmuth has been too often employed for the adulteration of Quickſilver, as rendering a very conſiderable proportion of Lead intimately miſcible with it: Becher was acquainted with means of combining no leſs than one drachm of Lead and the ſame quantity of Biſmuth with three drachms of running Mercury. Quickſilver ſo adulterated is not only unfit for medicinal uſe, but for the common mechanic purpoſes of gilding and ſilvering: the workmen obſerve, that

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(*x*) *Uſe of Biſmuth in cupellation.*] Biſmuth is particularly preferable to Lead for the cupellation of Gold or Silver blended with refractory matters; as it procures a greater tenuity of fuſion than Lead is capable of doing. Monſ. du Fay obſerves, that Gold is ſometimes met with very eager, pale, livid, and difficult of fuſion, from an admixture, as he ſuppoſes, of Emery; and that it is moſt effectually purified by means of Biſmuth. The method, which he communicated to the French Academy for its purification, conſiſts in melting it with an equal quantity of Biſmuth, and pouring out the fluid part, adding more Biſmuth to the remainder, and proceeding in this manner till the whole runs out clean, and then working off the Biſmuth upon a cupel; after which the Gold is to be again cupelled with the Lead; and laſtly, ſome corroſive Sublimate to be injected upon it in fuſion.

BISMUTH. it leaves upon the Gold or Silver a livid leaden hue. The abuſe is diſcovered, and the Mercury purified, by diſtillation. Some of the Wine-coopers have mixed Biſmuth with Sulphur for the fumigation of caſks, but as no good reaſon is alledged for this uſe of it, and as it may be productive of ill effects, it ought ſurely to be rejected. See Wepfer *de compoſitione noxia ſulphuratorum cum Biſmutho*; Camerarius's *ſylloge memorabilium medicinæ, cent.* 8, No. 23, and a paper by Dr. Salomon Reiſel, in the *Ephem. nat. curioſ. dec.* 3. *ann.* 5 & 6. Though Biſmuth, however, when thus corroded by the ſulphureous acid, and diſſolved in Wine, may produce dangerous effects; it does not follow that the Biſmuth in Pewter diſhes will communicate any ill quality to Vinegar or the other acids uſed in food; diſtilled Vinegar extracting nothing from Biſmuth without ſtrong coction.

Medical effects. This ſemimetal has been held by ſome in conſiderable eſteem as a medicine. The Magiſtery, the Calx, the Flowers, and ſundry other preparations of it, have been ſaid to be diaphoretic; to be ſerviceable in virulent gonorrhæas, gouty complaints, and contractions of the limbs. But experience affords little foundation for theſe virtues, nor even for ſuppoſing it to be ſafe. Some preparations of Biſmuth have ſeemed to repreſs febrile heat; but extreme anxiety, and other ill conſequences, have enſued.

Counterfeited. Biſmuth is extracted from its proper ore, which is found moſt plentifully in Saxony, near Schneeberg, and of which ſome quantities are met with alſo in Bohemia, and in England. Many have affirmed that it is an artificial compoſition, and accordingly delivered proceſſes for making it; of which proceſſes I tried thoſe which ſeemed to approach the neareſt to probability. Two ounces of Arſenic, one ounce of Verdegris, half an ounce of Sal gem, and half an ounce of oil Olive, were well ground together: three ounces of Engliſh Tin, melted with this mixture, yielded a Regulus weighing four ounces and two drachms, very brittle, of a grey colour, entirely different from Biſmuth in appearance as well as quality. But from four ounces of Engliſh Tin, two ounces of white Arſenic, one ounce of white Tartar, and half an ounce of Nitre, cemented and melted together, I obtained a Regulus, weighing three ounces and three drachms, ſo much reſembling Biſmuth, as to be eaſily miſtaken for it by one who had not thoroughly examined the appearance of that ſemi-metal. There are however ſome differences in the ſtructure of the two, very obvious upon comparing them together, but which are rather to be ſeen than deſcribed. In their intrinſic properties they are extremely different: thus the counterfeit, diſſolved in Aqua fortis, forms a bluiſh coagulum, whilſt the ſolution of the natural Biſmuth continues uniform and limpid; the counterfeit, calcined and mixed with Sulphur, exhibits nothing of that ſingular needled ſtructure, which the natural aſſumes in the ſame circumſtances. Since therefore it has been reported, that the Biſmuth met with in the ſhops is an artificial production, and ſince experiment ſhews that it is capable of being imitated in its external form, though not in its qualities, we ought to be upon our guard againſt ſuch an impoſition.

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Ores.

The ores of Biſmuth are met with chiefly in the mines of Silver and Cobalt. They are commonly of a ſparkling appearance, of a yellowiſh colour, or intermixed with yellowiſh veins; often reddiſh; often variegated with different colours, as bluiſh, reddiſh, and yellowiſh; and ſometimes quite black. The yellowiſh ſorts are called golden or philoſophic marcaſites, and have been held in great requeſt among the alchemiſts. By lying long in the open air, they yield beautiful red ſtriated efflореſcences, called by the miners Flowers of Cobalt or of Biſmuth.

Aſſay.

Biſmuth ores are aſſayed for Biſmuth by pulverizing, and melting them, in a cloſe crucible, with thrice their weight of black flux; a little charcoal duſt being ſpread upon the ſurface of the mixture.

The Regulus obtained by this proceſs is aſſayed for Silver, by calcining it with Nitre; which ſoon ſcorifies the Biſmuth, whilſt the Silver, if it contained any, remains unhurt at the bottom.

Smelting in large.

In the large way, the ore, beat into ſmall pieces, is placed in a low furnace or oven, ſo contrived, that the flame of the wood may play upon the ſurface of the mineral. The Biſmuth melts out, by a heat no greater than that in which pure Biſmuth melts, and runs off into a cavity made for receiving it; from whence it is taken out, and caſt, in moulds, into round cakes. Ercker has given a wooden cut of the manner of ſmelting Biſmuth ore; and from this is copied the copper-plate in Valentini's *muſæum muſæorum*. The matter remaining after the eliquation of the Biſmuth, called *Wiſſmuthgraupen*, Biſmuth-earth, or Caput Mortuum of Biſmuth is employed for making a blue glaſs, in the ſame manner as calcined Cobalt (*y*).

Experiments on the ore.

The crude ore, melted with colourleſs glaſs, or a fuſible compoſition of Sand and alcaline Salt, tinges it blue, deeper or paler, according to the proportions:

Blue glaſs,

on melting it with an equal weight of Nitre, the maſs proved likewiſe blue, but deliquiated in the air: with four times its quantity of the *Sal ammoniacum fixum*, it formed only a brown concrete, which being boiled in water, almoſt all the ore ſeparated, the liquor acquiring a ſlight yellowiſh tinge. A tincture drawn

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(*y*) *Biſmuth ore—blue glaſs*.] The ores of Biſmuth frequently accompany Cobalt, and always participate of its colouring matter, as Cobalt almoſt always does of Biſmuth. Probably, as Cramer obſerves, the two ores differ from one another only in this, that one contains more Biſmuth than the other.—The reſiduum of Biſmuth ore is ſaid to afford a glaſs of a finer colour than that of Cobalt; and hence Biſmuth has been held a mark of the goodneſs of Cobalt, and ſuppoſed to contribute to the beauty of the colour. This concluſion, however, appears to be too haſtily drawn; for moſt Cobalts ſeem to contain more Biſmuth, than Biſmuth ores do after eliquation. If the obſervation itſelf is well founded, it tends rather to prove that Biſmuth is injurious to the colour; more eſpecially as this ſemimetal is itſelf eaſily convertible into a yellow glaſs, which ſhould ſeem more likely to debaſe than to improve the blue colour of the Cobalt glaſs. The author of *Henckelius redivivus* mentions a Cobalt mine in Joachimſthal, abounding with Biſmuth, but yielding a glaſs of no value. See Cobalt.

drawn from the ore with Aqua fortis, mixed with a ſaturated ſolution of Sea-ſalt, and inſpiſſated, yields a reddiſh Salt, whoſe colouring matter diſſolves both in rectified Spirit of Wine and in water; a white earthy ſubſtance remaining undiſſolved. The red watery ſolution is the curious liquor, which has lately been kept a ſecret, under the name of the green ſympathetic Ink. It may ſeem an impropriety to give a red colour to the name of green; but this liquor is truly green, and of a fine green, when heated, as well as red whilſt cold; and in that ſtate wherein it is viſible as an Ink, it is always green. If written with on white paper, the characters diſappear as ſoon as they are dry: if the paper is held to the fire, they become green and legible; on cooling they diſappear again, and this repeatedly for any number of times (z.)

BISMUTH. changeable coloured liquor.

III. ZINC.

ZINC (*Zincum*, *Contrefait*, *Tutenag*, *Spiauter*, *Spelter*) is a white ſemimetal, inclining a little to bluiſh, eſpecially when compared with the whiter metallic bodies, Regulus of Antimony, Tin, or Silver. It is conſiderably hard and ſonorous, and leſs brittle than any of the other ſemimetals: hammered gently and leiſurely, it extends a little, but by a few quick blows, or a ſmart one, it cracks or breaks. In

ZINC. General properties.

(z) *Sympathetic Ink.*] This property of the tinging matter of Biſmuth-ore was publiſhed at full length by a German lady in 1705. The compilers of the *encyclopedie* attribute the diſcovery to Mr. Hellot; though that gentleman himſelf acknowledges that he received the firſt hint of it from a German chemiſt, no earlier than the year 1736. The experiment ſucceeds beſt, when the tincture drawn from the calcined ore with Aqua fortis is mixed with a ſolution of one fourth its weight of Sea-ſalt, the mixture evaporated almoſt to dryneſs, and the reſiduum diſſolved in water. Mr. Hellot has given a variety of experiments on this ſubject in the French Memoirs for the year 1737. He obſerves, that with Nitre or Borax, inſtead of Sea-ſalt, the characters become roſe-coloured when warmed, and, if Sea-ſalt is afterwards paſſed over them, blue; that, with Alcali ſufficient to ſaturate the acid, they change purple and red from heat.

ZINC. In ſpecific gravity it comes the neareſt to Tin; which laſt is ſomewhat the heavieſt of the two (*a*).

Examined by fire. It begins to melt in a moderate red heat (*b*); and when in fuſion, burns and fulgurates, with a deep, yellowiſh green flame, a conſiderable noiſe, and an arſenical ſmell: if the fluid metal is ſtirred, the deflagration continues ſtrong, till nearly the whole quantity is deprived of its metallic form and ſublimed into flowers, which concrete about the upper part of the veſſel into fine, ſoft, white filaments, like down or cobwebs (*c*). It is obſervable, that in a broad Iron ladle, Zinc in filings will not melt near ſo ſoon as the ſame quantity in one piece; whereas, when bodies are reduced into ſmall parts, they commonly melt the ſooneſt: the difference in this caſe probably ariſes from the filings expoſing a larger ſurface to the external air, and the communication of the heat being intercepted

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(*a*) *Zinc.*] This ſemimetal makes a crackling noiſe in bending, like that of Tin, but louder: broke, it appears internally of a fiſſile plated texture, partly dull-coloured, partly bright and ſparkling. Expoſed to the air, it contracts, in length of time, a kind of yellowiſh ruſt. It is ſomewhat ductile when cold, but when heated proves entirely brittle. Its ſpecific gravity is to that of water as $7\frac{1}{10}$ to 1.

(*b*) *In the fire.*] It begins to melt as ſoon as it grows red-hot; but does not flow thin, or burn, or ſublime, till the fire is raiſed to a white heat. Kept juſt in fuſion, it calcines, ſlowly, not only on the upper ſurface, but likewiſe round the ſides, and at the bottom of the crucible: If ſeveral pieces are juſt melted together, the maſs, when grown cold, may be broke into the ſame number, their union being prevented by a yellowiſh calx, with which each piece is all over covered. Malouin relates, in the French Memoirs for the year 1742, that a quantity of Zinc being melted ſix times, and the fuſion continued fifteen hours each time, it proved, on every repetition, harder, more brittle, leſs fuſible, and leſs calcinable; that, after the two firſt fuſions, its colour was grey; after the third, brown; and, after the fourth, black; that the fifth rendered it of a ſlate blue; and the ſixth, of a clear violet.

(*c*) *Flowers.*] The flowers once ſublimed from this ſemimetal are no longer capable of being elevated by the ſtrongeſt fire. In a heat far greater than that in which they aroſe at firſt, they ſuffer no alteration; in a very vehement one they melt, according to Henckel, (*Act. Nat. Cur. tom.* iv.) into a ſemi-opake green glaſs: vitrified with Borax, they give a grey or browniſh glaſs.——From the ſingular texture of the flowers, they have been called philoſophic Wool, Cotton, Silk, and Talc: from the ſtrong green flame with which they ſublime, they are ſuppoſed by ſome to be the ſubſtance veiled by alchemiſts under the titles of the golden fleece guarded by fiery bulls, and the dry water extracted from the ſun-beams; and the ſemimetal itſelf to be the Sun, the Lucifer, the green Lion, and the Dragon that vomits fire.

intercepted by the vacuities betwixt them: the filings ſtrewed upon burning coals, melt and deflagrate much ſooner than larger pieces. The face, viewed by the flame of Zinc, looks like that of a dead corpſe: the flame of Phoſphorus, and Spirit of Wine impregnated with Sea-ſalt, exhibit the ſame phœnomenon.

Flowers.

The veſſels commonly made uſe of for ſubliming flowers of Zinc, are two crucibles; one placed in the fire, for containing the Zinc; the other inverted upon it by way of cover: this laſt is every now and then taken off, and the Zinc ſtirred. Some perform the ſublimation in a wide necked glaſs retort; others in an earthen body, *&c.* I have made a great number of experiments for determining the moſt ſucceſsful method, and the moſt commodious apparatus: I have tried open and covered crucibles, earthen and glaſs retorts, gentle and ſtrong fires, large and ſmall quantities, with and without ſtirring, in ſhort, all the different ways I could think of. In this examination it appeared, (1.) That Zinc does not begin to ſublime when it begins to melt, but may be kept a good while in fuſion without deflagration or diſſipation. (2.) That the ſublimation commences with the burning and noiſe. (3.) That by a ſtrong fire, in an open crucible, a conſiderable quantity, commonly one fourth its weight, is totally diſſipated; but that, by a gentler heat, the loſs is much leſs. (4.) That glaſs retorts are intirely unfit for this purpoſe, as they are apt to crack from the heat neceſſary to keep the Zinc in fuſion, and as the ſublimation, if they happen to ſtand the fire, does not well ſucceed in them. (5.) That earthen retorts anſwer better, but that theſe alſo are liable to an inconvenience; a groſs Sublimate ariſes after the finer flowers, and, in breaking the neck of the retort, we cannot avoid mingling the two together. (6.) That when two crucibles are uſed, the more ſubtile flowers, whoſe quantity is but ſmall, ariſe into the uppermoſt; the more ponderous remaining in the lower, adhering to its ſides, and filling

ZINC. filling the veſſel, as it were, with a ſubſtance like burnt Alum, which proves more and more compact and groſs from the top to the bottom. (7.) That the flowers already ſublimed muſt, if we expect any more Sublimate, be from time to time taken away; Zinc requiring room, and the acceſs of freſh air, for its ſublimation. In ſtirring the Zinc, or removing the flowers, care muſt be had that none of them fall down upon the melted Zinc; for if they do, they will never riſe again, but remain a fixt calx, covering the metal and preventing its ſublimation. The beſt method, upon the whole, appears to be this: a large crucible being placed in a wind-furnace on a piece of brick, and made moderately red-hot, but not too ſtrongly heated, the Zinc is to be thrown in, in pieces: the crucible may be covered till the Zinc begins to burn, but after this period it ſhould be kept open: when any conſiderable quantity of flowers is obſerved in the crucible, they are to be cautiouſly taken out with an iron ladle, and this continued till nothing more will ariſe, or till the whole quantity of the Zinc is burnt. By this method the produce of flowers is greateſt; greater even than the weight of the metal employed: from half an ounce I obtained half an ounce and fifteen grains.

Reduction of the flowers.

I have made ſundry experiments for reducing the flowers of Zinc into Zinc again. I urged them in a crucible with tallow; but they ſcarce changed their colour; I treated them with Pitch and with Wax, but obtained only a blackiſh grey powder. Two drachms of the flowers were put into a coated earthen retort, with an ounce of powdered Charcoal, and a receiver containing ſome water cloſely luted to the retort: the fire was raiſed by degrees, and kept up ſtrong for ſome hours, that there might be no deficiency in point of heat: but, upon unluting the veſſels, I found in the neck of the retort only a yellow and grey Sublimate, with a few ſparkling metallic particles: the coal at the bottom weighed ſix drachms and one ſcruple: a ſkin appeared upon the water in the receiver, and a little powdery matter ſubſided. The experiment was repeated, with the addition of ſome Beef-ſuet to the Charcoal, and without any water in the receiver; but this time I obtained only an empyreumatic Oil from the Suet. Sundry trials were made likewiſe with alcaline Salts and Borax, without ſucceſs. At laſt, having melted one drachm of the flowers with ſix drachms of Borax, in a quick fire, injected pellets of powdered charcoal made up with fat, and quenched the crucible in water, I found, on breaking the veſſel, ſmall granules of revived Zinc, with a blackiſh grey ſemivitreous ſcoria. It appears from the whole, that the reduction of theſe flowers, though difficult, is not impracticable: probably more ſucceſsful methods might be diſcovered, if the enquiry was of any particular utility or importance (*d*). ZINC.

I have ſometimes granulated Zinc, by pouring it, when melted, into a wooden box, well rubbed all over on the inſide with Chalk, and ſtrongly ſhaking it; but, in all the experiments with Menſtrua, I uſed filings. It ſeems as if part of the file was abraded by the Zinc, ſome of the particles being attracted by the Magnet;

(*d*) *Reduction of the flowers.*] From the difficulty of recovering Zinc from its flowers and calces, the chemiſts have been led to ſuppoſe either that they are irreducible, or that the phlogiſtic principle of Zinc is of a different kind from that of other metallic ſubſtances. A more careful examination has diſcovered, that ſuch inflammable matters as reduce other calces, reduce equally thoſe of Zinc; and that the difficulty lies, not in the reviving, but in preſerving this volatile ſemimetal after its revival. All calces, thoſe of Iron excepted, require a ſtronger fire for their reduction than that in which the metal itſelf melts; and a full melting heat is the greateſt that Zinc can ſuſtain: hence, in the inſtant of its revival, it burns and calcines again if the air is admitted, and in cloſe veſſels eſcapes, at leaſt in part, through their pores. On mixing flowers of Zinc with powdered Charcoal, and urging them with a ſtrong fire in a crucible, a deflagration and freſh ſublimation enſue; ſufficient marks that the Zinc has been reduced into its metallic form: for, ſo long as it remains in the ſtate of calx, neither of theſe effects can happen. If the veſſel is ſo contrived as to exclude the air, and at the ſame time allow the reviving ſemimetal to run off from the vehemence of the heat into a receiver kept cool, the Zinc will there concrete and be preſerved in its perfect metallic ſtate. It is ſtill more effectually detained by the addition of certain metallic bodies, as Copper and Iron; with which the Zinc, when thus applied, unites more readily and perfectly than it can eaſily be made to do by other means.

ZINC. Magnet; and this may poſſibly happen alſo in the filing of other metals, though not hitherto obſerved. Granulated Zinc is not touched by the Magnet.

treated with Oil of Vitriol, Oil of Vitriol did not diſſolve Zinc, though an ounce of the acid was taken to half a drachm of the metal: after ſeveral days digeſtion, the filings were only corroded into a white calx. Spirit of Vitriol made a complete ſolution: its action was accompanied with a conſiderable heat, and an inflammable vapour, like that which ariſes during the diſſolution of Iron. At firſt a grey and blackiſh, ſpongy, flaky matter ſeparated and aroſe to the ſurface, and ſoon after fell to the bottom, but, on ſtanding for ſome days, was taken up, and diſappeared in the liquor, nothing being left but a little yellowiſh duſt ſcarcely worth mentioning. The liquor is as limpid and colourleſs as the Spirit of Vitriol itſelf.

with nitrous acid, Spirit of Nitre or Aqua fortis has a ſtronger appetite for Zinc than any other acid, and than this acid has for any other metal. It acts with great violence and heat, and a copious diſcharge of reddiſh-yellowiſh-brown vapours; and preſently diſſolves almoſt the whole of the Zinc into a colourleſs tranſparent liquor.

with marine acid, Spirit of Salt likewiſe attacks Zinc very readily; but does not act near ſo violently, or diſſolve it ſo expeditiouſly, as Spirit of Nitre. A little fine blackiſh ſubſtance appears during the diſſolution, nearly like that which ſeparates with Spirit of Vitriol: but this alſo is at length diſſolved, only an inconſiderable portion of duſty matter remaining. The liquor is almoſt colourleſs, or very ſlightly yellowiſh.

with Aqua regia, Aqua regia acts on Zinc pretty violently, and diſſolves it ſpeedily, leaving, as in the foregoing experiments, a very little powdery matter. This ſolution is of a citron yellow colour; in which reſpect it differs from all the others. When an Aqua regia made with Sal ammoniac was employed, ſome ſmall cryſtals of Zinc ſhot at the bottom.

Diſtilled Vinegar ſeems at firſt to have little action on this ſemimetal; but, on digeſting an ounce of the acid with half a drachm of the filings, half a ſcruple was at length taken up. The ſolution looked milky, and had a ſweetiſh taſte reſembling that of ſaturnine ſolutions: on filtration it became clearer, and, on ſtanding, ſtill more ſo; a little powdery matter having been left upon the filter, and a little more gradually depoſited to the bottom of the liquor.——Two drachms of filings of Zinc being boiled in water with an ounce and a half of powdered Tartar; the liquor, paſſed through a filter, was found to have loſt its acidity, and acquired a metallic taſte; and the Zinc to have loſt a ſcruple of its weight. with vegetable acids,

Alcalies, both fixt and volatile, were digeſted with filings of Zinc for a fortnight, but neither of them ſeemed to have made any ſolution. The metal appeared to be however in ſome meaſure corroded; the ſuperficial part having loſt its metallic aſpect, and changed to a black colour. In the filings which had been digeſted with the volatile ſpirit, ſome fine white particles were intermixed among the black, as if they had been taken up and depoſited again by the liquor. with alcalies.

The flowers of Zinc did not diſſolve in Oil of Vitriol, any more than the ſemimetal itſelf; but, like it, they diſſolved in Spirit of Vitriol, and in the other acids. To try whether they retained any of the inflammable principle, of which Zinc ſo plentifully partakes, I evaporated a ſolution of them in the nitrous acid to dryneſs, and made the dry matter red-hot. It did not burn or deflagrate, which any inflammable ſubſtance, treated in the ſame manner with the nitrous acid, would have done. Homberg, however, pretends to have obtained an actual Oil from them: he diſſolved ſome of the flowers in diſtilled Vinegar, by digeſting them in freſh parcels of the acid; and diſtilled the ſolutions in a glaſs retort: at firſt a quantity of phlegm aroſe, then the ſuperfluous acid, and at laſt an empyreumatic Oil. This Oil, Flowers; with acids,

though

ZINC. though diſtinguiſhed by the titles of *Oleum florum Zinci*, *Oleum minerale*, and *Oleum metallicum*, is obviouſly no other than a fetid tartareous Oil proceeding from the Vinegar. He endeavoured to evade this objection, by pretending to make the ſame kind of Oil by Spirit of Vitriol, without Vinegar; but the experiment has never ſucceeded *(e)*.

Precipitations. That Zinc precipitates Iron, Copper, and other metallic bodies from the nitrous acid, and conſequently has a greater affinity with that acid than the other metals have, was obſerved by Stahl. That it precipitates Copper from the vitriolic acid, is alſo known: and that it precipitates Iron likewiſe from the vitriolic acid, is believed, though this particular ſtill wants a further examination. I diſſolved pure Vitriol of Iron in diſtilled water, and added to the filtered ſolution large pieces, ſmaller pieces, and filings of Zinc, in the proportion of a drachm to an ounce of the Vitriol; digeſted the mixtures with a conſiderable heat; and at laſt kept them for a time actually boiling. Some precipitate there was, but apparently no more, and no other, than what the Vitriol itſelf would have depoſited on the ſame treatment. The filtered liquor ſtill yielded greeniſh cryſtals. The Zinc looked blackiſh-grey on the ſurface, but retained its original weight, and diſſolved in Aqua fortis into a colourleſs liquor, a mark that it retained none of the Iron. From the opinion of Zinc having a greater affinity with the vitriolic acid than Iron has, Glauber, Stahl, and others have affimred affirmed that the acid may be diſtilled from Vitriol, by the addition of Zinc, with leſs heat, and in a ſhorter time, than without addition. How far this aſſertion agrees with experiment will be conſidered under the article Vitriol. Some recommend Zinc to be employed alſo in the diſtillation of the other mineral acids; but if a pure acid is wanted, this addition is by no means adviſable; part of the Zinc being apt to ariſe, when the heat is increaſed to any conſiderable degree. It has been ſaid, that Spirit of Vitriol, and Spirit of Salt, precipitate Zinc from its ſolution in Spirit of Nitre. On trial Spirit of Salt occaſioned no precipitation, and Spirit of Vitriol threw down only a little greyiſh matter, like that which ſeparates during the diſſolution of Zinc when the vitriolic acid is applied to it at firſt.

(e) *Oil from Zinc with Vinegar.*] Mr. Hellot obtained an oil ſeemingly different from the foregoing, by digeſting the aſh-coloured matter which remained after the diſtillation, with the acidulous phlegm which came over, for eight or ten days; diſtilling the tincture to dryneſs; and repeating the extraction with the diſtilled liquor, till the quantity of dry extract thus obtained was conſiderable. This reſin-like matter, diſtilled in a retort with a ſtronger fire, yielded a yellowiſh liquor and a white Sublimate. The liquor diſcovered no mark of oil, but on being paſſed upon the Sublimate, immediately diſſolved it, and then exhibited on the ſurface ſeveral drops of a reddiſh oil. Some of this oil was taken up on the point of a pencil, and applied on gold and ſilver-leaf. In twenty-four hours, the parts touched appeared, in both, equally diſſolved.

Treated with Sal ammoniac.

Equal parts of filings of Zinc and powdered Sal ammoniac, being mixed together, and urged with a gradual fire in a retort; at firſt aroſe, in a very gentle heat, an exceſſively penetrating volatile ſpirit, ſo ſtrong as to ſtrike a man down who ſhould inadvertently receive its vapour freely into the noſe. This came over in ſubtile vapours, and was followed by a volatile Spirit of Salt in thick white fumes. In an open fire, white flowers ſucceeded, and at length a reddiſh and a black Butter. In the bottom of the retort was found a portion of the Zinc in its metallic form, with a little ponderous and fixt butyraceous matter, which liquefied in the air. The lump was far more brittle than Zinc ordinarily is, of a reddiſh colour on the outſide, and blackiſh within. The bottom of the retort was variegated with yellow and red colours, and looked extremely beautiful. The remaining Zinc was mixed afreſh with equal its weight of Sal ammoniac, and the proceſs repeated. A volatile alcaline ſpirit and marine acid were obtained as at firſt, and in the retort was found only a little black matter. When the Zinc was taken at firſt in twice the Quantity of the Sal ammoniac, the part that preſerved its metallic form

ZINC. proved leſs brittle than in the foregoing experiment; the retort appeared variegated in the ſame manner. On endeavouring to rectify the butter, the retort parted in two by the time that one half had diſtilled.

Amalgamation. Melted Zinc, poured into heated Quickſilver, readily amalgamates. One drachm of Zinc, and two or three drachms of Mercury, form a hard brittle amalgam; one part of Zinc and five of Mercury, a ſoft one. Equal parts of Zinc and Lead, melted together, and poured into ſix times their weight of Quickſilver, yielded a ſoft butyraceous amalgam, which, ground with water, gradually threw out the Zinc, whilſt the Lead remained united with the Mercury.

with Lead, It is affirmed in books, that a little Zinc thrown upon melted Lead, will inſtantly take fire, and calcine the Lead. On an ounce of Lead in fuſion, I injected a drachm of Zinc, but no flame or calcination enſued. The Lead, when cold, looked brighter, whiter, and harder. Two drachms being injected on an ounce, part of the Zinc ſwam long upon the ſurface, and ſeemed averſe to unite with the Lead, though they were frequently ſtirred together. Equal parts united, by a ſufficient heat, into a compound harder and more brittle than the Lead, and which in bending made a crackling noiſe. As no deflagration happened in theſe experiments, I inverted the procedure, melting the Zinc in a crucible by itſelf, and injecting upon it different proportions of Lead. The Zinc now fulgurated inſtantly on the contact of the Lead, and ſublimed into flowers, leaving the Lead in its metallic form at the bottom of the crucible: the flowers were extremely fine, and had often a reddiſh caſt.

compound metals, Pewter, Bronze, &c. The principal uſe of Zinc is in metallic compoſitions (*f*), the baſis of which is always either Copper or Tin.

(*f*) *Zinc with other metals.*] Zinc does not mingle in fuſion with Biſmuth or the ſemimetallic ſubſtance called Nickel. How carefully ſoever it be ſtirred and mixed with either of theſe, the Zinc, when grown cold, is found diſtinct upon the ſurface, ſo as to be readily ſeparated

ZINC.

Tin. It renders Copper of a yellow or Gold colour, Tin brighter and whiter, and both of them harder and more ſonorous. The finer kinds of Pew-

ſeparated by a blow. It unites difficultly with Iron, leſs ſo with Copper, eaſily with the other metals.

Combined with Iron or Copper, it renders them more eaſily fuſible, harder, and like itſelf brittle whilſt hot, though conſiderably malleable when leiſurely cooled. It brightens the colour of Iron almoſt into a ſilver hue; and changes that of Copper to a yellow or gold colour. — It greatly debaſes the colour of Gold, and deſtroys its malleability; rendering near an hundred times its weight of that moſt ductile metal brittle and intractible. A mixture of equal parts of each is very hard, white, and bears a fine poliſh, and hence is propoſed by Mr. Hellot for making Specula. It is not ſubject to ruſt or tarniſh in the air, like the metals commonly made uſe of for that purpoſe, of which Copper is the baſis. —— It improves the colour and luſtre of Lead and Tin, renders them firmer, and conſequently better fitted for ſundry mechanic uſes. Tin, with a ſmall proportion of Zinc, forms a fine kind of Pewter. Lead will bear an equal weight, without loſing too much of its malleability. — Malouin obſerves, that Arſenic, which whitens all other metals, renders Zinc black and friable; that when the mixture is performed in cloſe veſſels, an agreeable aromatic odour is perceived on opening them; that Zinc, amalgamated with Mercury and afterwards recovered, proves whiter, harder, and more brittle than before, and no longer crackles on being bent.

Mixtures of Zinc with other metals expoſed to a ſtrong fire, boil and deflagrate more violently than Zinc by itſelf. Some globules of the mixture are uſually thrown off during the ebullition, and ſome part of the metal calcined and volatilized by the burning Zinc: hence this ſemimetal has been called metallic Nitre. Gold itſelf does not entirely reſiſt its action. —— It very difficultly volatilizes Copper; and hence the Sublimates obtained in the furnaces in which Braſs is made, or mixtures of Copper and Zinc melted, are rarely found to participate of that metal. On melting Copper and Zinc ſeparately, and then pouring them together, a violent detonation immediately enſued, and above half the mixture was thrown about in globules.

Zinc with Sulphur.] Zinc does not unite in the leaſt with Sulphur or with crude Antimony, which ſcorify all other metallic ſubſtances except Gold and Platina; nor with compoſitions of Sulphur and fixed alcaline Salts, which diſſolve Gold itſelf. Hence Zinc may be purified from the Lead, of which it commonly has ſome admixture, by injecting Sulphur upon it in fuſion; the Lead being abſorbed by the Sulphur, and forming with it a concrete which floats unmelted on the ſurface and may be eaſily ſcummed off.

Zinc with Nitre.] Zinc deflagrates violently with Nitre. Its flowers do not ſenſibly deflagrate, yet alcalize double their weight of the Salt, more readily than Zinc itſelf. The alcaline maſs appears externally greeniſh, internally of a purple colour. It communicates a fine purple to water, and a red to Vinegar. The acetous tincture, inſpiſſated, leaves a tenacious ſubſtance, which ſoon runs in the air into a dark red cauſtic liquor, the alcaheſt of ſome of the pretended adepts. Mr. Hellot obſerves that this liquamen, far from radically diſſolving Gold as it has been ſaid to do, precipitates and revives it from its ſolution in Aqua regis.

Zinc. ter have an admixture of Zinc, the proportion of which to the Tin is kept a ſecret by the workmen. It is often very ſmall, and ſometimes does not amount to above a pound in five or ſix hundred pounds of Tin. Princes-metal is a mixture of Zinc and Copper; and all the compound metals made in imitation of Gold are at bottom the ſame, differing only in the proportions and ſome other circumſtances which contribute to the malleability or colour. Mr. Geoffroy, in the French Memoirs for the year 1725, has given an account of ſeveral experiments on this ſubject: the compoſitions which he found to anſwer beſt are the three following. (1.) Two ounces of Copper, one ounce of Zinc, and four ounces of Reſin. Theſe yielded a pale, but a malleable metal. (2.) Equal parts of Zinc and Braſs. This mixture was much higher coloured than the foregoing, but a good deal more brittle. (3.) One ounce of Copper, ten drachms of Zinc, and one drachm of Iron. All theſe compoſitions require a conſiderably ſtrong fire for their fuſion. It is obſervable that Mercury-ſublimate ſeems to deſtroy that quality in Zine by which it makes Copper brittle; and hence is made uſe of by thoſe who bronze Copper, or render it ſuperficially yellow, in order to its being drawn into wire for laces. Such is the ductility of Copper and Zinc ſo prepared, that the wire and laces, notwithſtanding their great tenuity, remain every where coated with the Bronze, and diſcover nothing of the Copper underneath. A certain perſon in Saxony has lately diſcovered a ſubſtance, of which a ſmall portion, injected into a large quantity of melted Copper, changes the Copper into a yellow or Princes-metal: this is perhaps ſome concentrated preparation of Zinc. The original diſcovery of Princes-metal is attributed by ſome to prince Rupert, and from him alſo its name is ſuppoſed to have proceeded. Others obſerve, that it was in uſe long before the time of Rupert, for caſting ſtatues, &c. and that the name Princes-metal is no other than a corruption of Bronze metal.

Spelter ſolder.

Zinc and Spelter are commonly underſtood, both by chemical writers and by workmen, as ſynonymous names for the white ſemimetal we have been treating of. In England a yellow metallic body, uſed as a ſolder, is diſtinguiſhed by the name of Spelter, and ſuppoſed by many to be a particular kind of Zinc naturally yellow. I have been told by ſome, that it is found in Cornwall; by others that it comes from America; but have never met with one who could give any ſatisfactory account of its origin; and ſuſpect it to be no other than an artificial compoſition of Zinc and Copper [which it is now known to be.] Thus much is certain, that pure Zinc is never yellow.

Zinc not artificial.

Zinc itſelf has been held by many to be an artificial compound, and many ridiculous conjectures have been advanced about the manner of its production. Some have confounded it with Biſmuth, with Tin, with different metallic mixtures; and Dr. Schmieder, in the *Eph. nat. cur. cent.* 3 & 4. is whimſical enough to believe, that the filaments which we often find hanging in the air in ſummer, from the induſtry of the ſpider, are true flowers of Zinc. Homberg prepared a metalline cobweb-like matter, which it was more natural to miſtake for flowers of Zinc, by expoſing Tin and Iron to Tſcirnhaus's burning-glaſs. I repeated the experiment with the ſame glaſs, and obſerved that as ſoon as ſome Tin was added to the melted Iron, fine ſlender filaments immediately aroſe, and flew all about, ſticking to our clothes, and to the machine. They differed, however, even in their obvious appearances from the flowers which Zinc affords, being not only longer, but in ſome degree tough and flexible.

Method of obtaining at Goſlar.

The greateſt quantities of Zinc come from the Eaſt-Indies, in large oblong pieces; and from Goſlar, commonly in round cakes or loaves. Of the origin of the Eaſt-India Zinc, we have no certain account. The

ZINC.

The Goſlarian is extracted from the Lead and Silver ores of Rammelſberg by a particular contrivance in the ſtructure of the furnace. The Zinc, naturally contained in the ore, ſeparates during the fuſion from the other metallic matters, being elevated by the heat in form of fume, which paſſes into a reſervoir made for that purpoſe in the front wall, over the gutter by which the Lead runs off. The reſervoir for the Zinc is incloſed, on the inſide, by a large flat ſtone, only ſome chinks being left for the fumes to enter; and on the outſide, by another ſtone, which is cloſely luted, and frequently ſprinkled during the proceſs with cold water, to cool and condenſe the fumes. Each ſmelting laſts twenty hours, beginning at ten in the forenoon, and ending at ſix next morning. When the fuſion of the ore is completed, the workman dextrouſly ſtrikes the outer ſtone of the reſervoir with an Iron rod, ſo as to looſen ſome of the luting at the bottom; upon which the Zinc, collected during the proceſs, runs out like Quickſilver. He continues to tap till no-nothing more will run, then melts the Zinc again in an Iron pot, and caſts it into hemiſpherical maſſes. I have ſeveral times been at this work, and kept at it two days and a night together without leaving the furnace.

Though a part of the Zinc is thus obtained in its metallic form, a part is alſo diſſipated, and a very conſiderable one adheres to the ſides of the furnace in the form of a calx. This is ſcraped off when the furnace is cold, and employed for the making of Braſs, &c. under the name of *Ofenbruch*, or *Cadmia fornacum*. There are ſundry other Lead-ores which yield the ſame kind of Sublimate; but no attempts have been made to extract actual Zinc from them, nor is it generally known that this Sublimate proceeds from Zinc. The produce of Zinc is extremely variable, and depends in great meaſure, not only on the due contrivance of the cavity for receiving it, but on the care of the workman in cooling it with water.

Zinc.

water. At Goſlar, when the due precautions happen to be neglected, there is not ſo much Zinc detained as to be worth collecting.

Calamine. An ore of Zinc.

To change Copper to a yellow colour is one of the moſt diſtinguiſhing characters of Zinc. The *lapis calaminaris*, *cadmia foſſilis*, Calamine or Calamy, is well known to poſſeſs this property, being the ingredient commonly employed for turning Copper into braſs. It makes a finer Braſs than the *Cadmia fornacum*, the latter participating of the Lead, which the ore it is obtained from abounds with. Calamine appears therefore to belong to the ſame family with Zinc; to be in reality an ore of that ſemimetal, though not hitherto worked for it.

Natural hiſtory.

Calamine is conſiderably ponderous, the more ſo the better; moderately hard and brittle, or of a conſiſtence betwixt that of ſtone and earth; ſometimes whitiſh or grey; ſometimes yellowiſh or of a deep yellow; ſometimes red; ſometimes brown or blackiſh. It is plentiful in ſeveral places of Europe, as Hungary, Tranſylvania, Poland, Spain, Sweden, Bohemia, Saxony, Goſlar, France, and in England, particularly in Somerſetſhire, and the northern parts of Wales. It ſeldom lies very deep, being chiefly found in clayie grounds near the ſurface. In ſome places it is intermixed with Lead ores. It is generally waſhed from ſuch impurities as may adhere to it externally, and calcined in kilns, like thoſe in which lime or bricks are burnt, before it is brought into the ſhops or to the Braſs-maker. I have obſerved, in ſome Braſs-works, that when the Calamine had not been calcined ſufficiently, the workmen have been obliged to calcine it over again themſelves. Merret informs us, in his notes on Neri, that it muſt be burnt only to a certain degree; that when too little calcined, it does not unite with the Copper; and that when over calcined, it makes the metal brittle.

Braſs.

The Braſs-makers reduce the calcined mineral into fine powder, in ſtamping-mills turned by water. To an hundred

CALAMINE.

hundred pounds of Copper, in ſmall pieces, they take forty pounds or more of the powder mixed with a certain quantity of powdered Charcoal; and divide the mixture into ſeveral crucibles, ſix or eight of which are let down into one furnace ſunk in the ground. The proceſs is no other than a cementation, which is continued for different lengths of time according to the quality of the Calamine, ſometimes for a day and night, ſometimes two, three, and even five days and nights. The Copper being at length changed into Braſs, and brought into fuſion, the crucibles are taken out, one after another, and the metal caſt into a plate betwixt two large flat ſtones prepared for this uſe.

Often one third of the Calamine is taken up by the Copper; though ſome ſorts of Calamine are ſo poor as not to give out above one tenth of their weight *(g)*. The Zinc thus introduced into the Copper may be ſeparated by amalgamation with Mercury, which unites with the Copper, and leaves the Zinc untouched; by fuſion with common Salt, which will ſcorify the Zinc; or by fire alone, which will burn and diſſipate it. If braſs leaf be held in the flame of a candle, the Zinc will inſtantly burn out in a flaſh like lightning, and the leaf will become Copper. It is obſervable that Copper impregnated with Calamine, proves much more malleable, and of a yellower colour, than mixtures of the ſame metal with equivalent proportions of Zinc in ſubſtance; probably from the common ſorts of Zinc participating of Lead: and that though both Zinc and Calamine change Copper to a golden colour, they greatly debaſe the colour of Gold itſelf, rendering it pale or white.

(g) *Quantity of Calamine taken up by Copper.*] One third the weight of the Calamine is the largeſt yield at the braſs-works, of which we have any account. This mineral however contains often a conſiderably greater proporton of metallic matter, capable of being imbibed by Copper, or ſeparated, by treating it with inflammable additions in cloſe veſſels, in the form of actual Zinc. From the common Calamine of the ſhops I have gained thirty-three parts on ſixty-four. The foreign Calamines appear, from ſome experiments related by Mr. Marggraf in the Berlin Memoirs, to be leſs rich than ours.

Examined by acids.

I examined ſeveral ſorts of Calamine by acid menſtrua, and found that they all nearly agreed. From all the ſorts the marine acid extracted moſt, and acquired a deep yellow colour; a mark not of their containing Gold, as ſome have fondly ſuppoſed, but Iron. Calcined with Oil or other inflammable matters, they yield actual Iron to the Magnet, and ſome hold ſo much as to afford a ferrugineous Vitriol. The Tinctures made in Aqua fortis are likewiſe yellow, though not ſo deep as thoſe in Spirit of Salt. — Out of ſixty grains of a pale reddiſh Calamine, half an ounce of Oil of Vitriol diſſolved ſeven grains, the ſame quantity of Spirit of Vitriol five grains, of Spirit of Nitre eight grains, and Spirit of Salt fourteen grains. Out of ſixty grains of yellow Calamine, half an ounce of Oil of Vitriol diſſolved eight grains, of Spirit of Vitriol ſeven grains, Spirit of Nitre twelve grains, and Spirit of Salt ſeventeen grains. As the vitriolic acid diſſolves ſo little of Calamine, I had little hopes of ſucceeding in an experiment related by a certain writer, of changing green Vitriol into white by precipitation with this foſſil. I proceeded exactly according to his directions, but obtained only a green Vitriol again. Many things are believed to be facts becauſe men of learning have written them, and yet when brought to trial are found to be falſe.

The Solution in Spirit of Nitre, evaporated to dryneſs, yielded a reddiſh-brown maſs, which on digeſtion with rectified Spirit of Wine, in a cloſe veſſel, exploded and burſt the glaſs. A ſaturated ſolution in the marine acid, concentrated by abſtracting or evaporating part of the liquor, exhibits in the cold an appearance of fine cryſtals, which on applying warmth diſſolve and diſappear. A little of this concentrated ſolution tinges a large quantity of water of a bright yellow colour, and at the ſame time depoſites by degrees a fine, ſpongy, browniſh Precipitate.

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Examined by diſtillation. I diſtilled four ounces of the reddiſh and the yellow Calamine in a retort in an open fire. From the reddiſh aroſe a drachm and a half of phlegm, which changed Syrup of Violets green; and ſome grains of an ammoniacal Salt, which yielded an urinous ſmell with fixt Alcali, effervesced with Oil of Vitriol and emitted a ſulphureous ſmell, made no change in the colour of Syrup of Violets, burnt in the fire with a bluiſh flame and ſulphureous fume. The Caput Mortuum was of a browniſh-red colour, weighed three ounces and ſeven drachms, and yielded no ſaline matter on elixation with water. From four ounces of the yellow Calamine, there aroſe three ſcruples and a half of phlegm, which changed Syrup of Violets green, but no Sublimate. The reſiduum weighed three ounces ſix drachms and a half, looked brighter coloured than the Calamine at firſt, and gave nothing ſaline on elixation. On diſtilling the Calamine with Pot-aſh, no remarkable difference was obſerved in regard to the quantity of Salt or urinous phlegm. A mixture of four ounces of Calamine and eight ounces of Nitre being injected by little and little at a time into a tubulated retort made red-hot, about a drachm of Spirit of Nitre came over, and in the neck of the retort was found a various coloured Sublimate. The reſiduum was compact, of a dark red

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red colour, and weighed ten ounces and ſix drachms. Calamine mixed with Sal ammoniac, yielded a yellowiſh Sublimate, like that obtained by the ſame means from hæmatites and other ferrugineous minerals; but of a paler colour, as containing leſs Iron. It does not in the leaſt unite with Quickſilver.

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Enquiry into its production.

There is another ſubſtance common in the ſhops, which may be referred to this head, as it changes, or ought to change, Copper yellow. This is called Tutty, *Tutia*, and by Lemery, *Tuthia*, in conformity perhaps to the Arabic origin which he aſcribes to it, though Avicenna, Serapio, Pliny, and many other ancient writers, (ſome of whom undoubtedly underſtood Arabic) call it *Tutia.* Pomet was the firſt who gave any particular account of this ſubſtance. He ſays it is brought into France from Germany, and ſome other places where Braſs or Bronze is made. Lemery adds Sweden, and ſays it comes from Germany, Sweden, and other places, *&c.* Savary, after copying theſe authors, makes another addition, that it is one of thoſe commodities which come from the Levant; a circumſtance which ſeems repugnant to the former part of the account. Avicenna and Serapio ſay it is found in the Indies; and Garcias denies its being met with in any part of the Indies. This gentleman was informed that it is made from the aſhes of a tree growing in Perſia, thence imported to Alexandria, and from thence into Europe. Bontius ſays likewiſe it is prepared in Perſia, but denies that it is from the aſhes of a tree. Juncker, profeſſor of chemiſtry at Hall, relates that it is made in Goſlar and at Schneeberg. And this is all I have found in books about the origin of Tutty.

With regard to Goſlar, I am well acquainted with all the works there, and fully ſatisfied that no Tutty is made at any of them. If made at Schneeberg, it ſurely could not have eſcaped the inquiries of the induſtrious Henckel, who lived many years in that neighbourhood, and ſat in the council of mines; and yet

TUTTY. yet we find him, in his Pyritologia, as much at a loſs about its origin as I am, and obliged to take up with Pomet's falſe account. I have written to Sweden, but there it is unknown. I have been at all the conſiderable founderies of Braſs, Bronze, Bell-metal, &c. in Germany and Holland, that at Woolwich and a noted one in Southwark in England, thoſe of France and Italy, &c. without being able to learn any thing of Tutty, or to find any perſon who knew what it was. Bontius's account, that it is a native earth found in Perſia and uſed as a depilatory, cannot be underſtood of our Tutty, which has no ſuch property.

Of the manner in which Tutty is prepared, and what it really conſiſts of, we know as little as of the places from whence it comes. Thoſe who make it a Sublimate ariſing in the founderies, ſay it concretes upon Iron or earthen cylinders placed in the furnace for that purpoſe, and that it is no other than a ſpecies of *Cadmia fornacum*. Valentina relates, that the cylinders are of wood, a material which would preſently be deſtroyed in the ſituation aſſigned to them.

A careful examination of Tutty itſelf diſcovers more of its origin than we can learn by any other means. Its baſis is apparently an argillaceous earth; among which we may diſcover an admixture of Calamine or *Cadmia fornacum*, ſometimes of Zinc in coarſe powder, ſometimes of Lead-ore, and ſundry other ſubſtances. On the ſurface are often found aſhes or bits of coal, which ſhew it to have been baked in the fire. Some years ago, Tutty was extremely ſcarce and dear at Berlin: all at once the ſhops were ſtocked, and the price fell. The Tutty now introduced had neither the colour nor compactneſs of the ordinary ſorts; nor was it ſo fixed in the fire; one half of it being diſſipated. We may therefore preſume, that Tutty is an artificial compoſition, and that this Tutty had been made, for a preſent advantage, by ſome perſon not thoroughly acquainted with the art.

The

Deſcription.

The better ſorts of Tutty are in ſemicylindrical concave pieces, like the bark of a tree; ponderous, and ſomewhat ſonorous; moderately compact, and generally not eaſy to break; of an aſh or mouſe-grey colour, often with yellow or green variegations; pretty ſmooth on the inſide, full of cavities or protuberances on the outſide. The entire, compact, grey pieces, are preferred; the broken, powdery, crumbly, yellow or reddiſh, rejected. Boecler relates that Tutty has a ſharp taſte, but no ſuch taſte is perceptible in ours.

Chemical examination.

In the following experiments was employed the beſt ſort of Tutty procurable from the ſhops, reduced into powder, in the quantity of ſixty grains with each liquor. (1.) Oil of Vitriol diſſolved fifteeen grains, acquired a red colour, and extricated fumes reſembling thoſe of Spirit of Sea-ſalt. (2.) Spirit of Vitriol took up twenty-four grains, and here alſo marine vapours were perceived. (3.) Spirit of Nitre diſſolved more than any of the other acids, namely twenty-eight grains out of the ſixty. The colour of the ſolution was a pale yellow. (4.) Spirit of Salt diſſolved twenty-ſix grains, and acquired a yellow tincture. (5.) Aqua regis diſſolved twenty-five grains, and became likewiſe ſlightly tinctured. (6.) Diſtilled Vinegar took up but two grains. (7.) Oil of Tartar per deliquium had no effect. (8.) Solution of cauſtic Alcali diſſolved ten grains. (9.) Different volatile ſpirits, prepared with fixt alcalies and with Quicklime, neither ſuffered or occaſioned any ſenſible alteration; though ſome report that theſe ſpirits extract from Tutty a blue tincture. Tutty extricates in ſome meaſure the volatile Alcali of Sal ammoniac, abſorbing and detaining the acid of the Salt. Neverthelеſs when Tutty is previouſly diſſolved in acids, volatile alcalies precipitate it. Stahl is not a little ſurprized at theſe ſeemingly oppoſite affinities: but Tutty is by no means the only inſtance of them. Pure calcareous earths exhibit the ſame phœnomena: expoſed to the fire in mixture with Sal ammoniac, they

TUTTY. they diſengage the Alcali, and unite with the acid; and when diſſolved in the acid, the addition of the volatile Alcali will precipitate the ſame earth by which it had been itſelf expelled before.

A piece of compact grey Tutty, heated fifty times red-hot, and quenched as often in diſtilled water, gave no impregnation to the liquor, and did not become crumbly or ſuffer any other ſenſible change than contracting ſome red and other coloured ſpecks. A yellowiſh and more brittle piece crumbled at the twentieth extinction, and changed its colour more than the preceding, but gave out nothing to the water. Tutty treated with inflammable fluxes, gave no metallic Regulus; with Borax, it was reduced into a vitreous ſcoria. Mixed with Charcoal powder, and cemented and fuſed with four times its weight of Copper, it tinged the metal yellowiſh. It were needleſs to proceed further in experiments upon a ſubſtance of ſuch precarious qualities; a ſubſtance of which we ſeldom meet with two ſpecimens entirely alike.

POMPHOLYX, &c. Some other productions of Zinc are mentioned by medicinal and metallurgic writers under various names, *Pompholyx*, *Diphryges*, *Nihil*, *Nihil album*, *Spodium græcorum*, *Cadmia botrites*, *zonites*, *onychites*, *oſtracites*, *placites*, *capnites*, &c. Theſe are truly what Tutty is pretended to be, impure ſublimates or flowers of Zinc, ariſing in the furnaces where Zinc, or Calamine, or compound metals made with them, are worked. A Sublimate of this kind is expected in the ſhops under the name of *Pompholix* or *Nihil*; but we ſeldom meet with the genuine Pompholyx there; maſſes compoſed chiefly of Chalk with probably a little white Lead, prepared in Saxony, commonly ſupplying its place. This counterfeit ſort is of a pure white colour; the genuine is greyiſh. The very beſt ſort is not equal, for medicinal or other uſes, to the flowers obtained from Zinc itſelf.

Calamine, Tutty, Pompholyx and the flowers of Zinc, are applied externally, in unguents and other forms, as deſiccatives and epulotics, againſt running ulcers, excoriations of the ſkin, and defluxions on the eyes. By ſome they have been exhibited alſo internally. It is ſaid that the flowers, given from ſix to twelve grains, prove ſometimes ſudorific, and ſometimes purgative or emetic. That a Magiſtery precipitated by ſpirit of urine from a ſolution of Calamine in Spirit of Salt, duly edulcorated and dried, is a moderately ſtrong emetic and cathartic. That a ſolution of Calamine in Spirit of Nitre, evaporated to dryneſs and ſlightly calcined, acts in doſes of ten grains or upwards, as a ſudorific. This preparation has been given by ſeveral perſons in England, and entitled *Sudorificum calaminaris*, and *Cadmia diaphoretica.* But the internal uſe of pure Zinc is ſcarcely adviſable; and that of its crude ore, whoſe contents are variable and uncertain, is ſurely leſs ſo. I knew an oculiſt, who employed this *diaphoretic* in Collyria with great ſucceſs: he digeſted the powder in Spirit of Wine, in the proportion of an ounce to to half a pint for a ſtronger preparation, and of two drachms to half a pint for a weaker. A little of the filtered liquor was dropt into the eye three or four times a day.

ZINC. Medical hiſtory.

IV. ANTIMONY.

ANTIMONY, (*Antimonium, ſtibium*) is a blackiſh mineral ſubſtance, ſtaining the hands, full of long, ſhining, needle-like ſtriæ, hard, brittle, and conſiderably heavy. It is found in different parts of Europe, as Bohemia, Saxony, Tranſylvania, Hungary and France, commonly in mines by itſelf, intermixed with earthy or ſtony matters. Sometimes it is blended with the richer ores of Silver, and renders the extraction of that metal difficult; Antimony volatilizing a part of the Silver, or, in the language of the miners, robbing the ore. Antimony is ſepa-

ANTIMONY. Natural hiſtory

ANTIMONY. rated from its natural impurities by fuſion in an earthen pot, whoſe bottom is perforated with a number of holes; the fluid Antimony paſſing through, whilſt the unfuſible matters remain behind. The melting veſſel is let into another pot ſunk in the ground, and which ſerves as a receiver. This laſt is of a conical figure, and ſuch accordingly is the ſhape of the loaves of Antimony met with in the ſhops. The juncture of the two veſſels is cloſely luted; the uppermoſt one covered, and a fire made round it; and ſeveral ſets of this apparatus worked at once. In ſome places inſtead of a pot with a perforated bottom, one is taken which has no bottom, and a perſorated iron plate placed betwixt it and the receiver: but the other method is to be preferred, as Antimony in fuſion is apt to diſſolve a part of the Iron.

Medical hiſtory. Antimony has been by many eſteemed a poiſon. In 1566, its uſe was prohibited in France by an edict of parliament; and, in 1609, one Beſnier was expelled from the faculty for having given it. The edict was repealed in 1650; Antimony having a few years before been received into the number of purgatives. In 1668, a new edict came forth, prohibiting its being uſed by any one but the doctors of the faculty. Others again have been extravagantly fond of it, and aſcribed to it extraordinary virtues, as Alexander von Suchten, Glauber, and Faber. Baſil Valentine ranks it among the wonders of the world, and placed it in a triumphal car. Thus much is certain, that Antimony in its crude ſtate is not a poiſon, but a medicine of great efficacy; an excellent reſolvent and purifier of the juices, if given from four grains to half a drachm, along with abſorbents. That it is capable of being rendered, by various operations and additions, either truly poiſonous, or more medicinal than in its crude ſtate. That its moſt virulent preparations may, by ſlight managements, be made ſalutary; and its moſt ſalutary ones, virulent.

Compoſed of Regulus and Sulphur.

Antimony is not a pure ſemimetal, but a ſulphurated ſemimetal. Thrown into the fire, it burns with a blue flame and ſulphureous vapours: on digeſting powdered Antimony in Aqua regia the metallic part is diſſolved, and the Sulphur left. The Sulphur of Antimony, purified from the metallic part, is perfectly the ſame with the common Brimſtone of the ſhops, poſſeſſing the ſame properties, and anſwering the ſame uſes: if the ſemimetal, freed from the Sulphur naturally mixed with it, be afterwards melted with common Brimſtone, it reſumes the appearance and qualities of crude Antimony. Many have imagined that this mineral, beſides common Sulphur, contains a golden or ſolar Sulphur; becauſe Antimony purifies, and heightens the colour of, Gold, and becauſe it diſſolves, as Gold does, in Aqua regia. But with regard to the ſolubility in Aqua regia, it is not the ſulphureous but the metallic matter of the Antimony that diſſolves: if nothing beſides Gold and Antimony was acted upon by that menſtruum, there might be ſome plauſibility in the argument; but ſurely when ſo many ſubſtances diſſolve in it, as Iron, Copper, Lead, Tin, Quickſilver, Zinc, various earths, &c. ſolubility in Aqua regis can be no proof of a ſolar impregnation. In the purification of Gold, the Sulphur of Antimony has no other effect than common Brimſtone would equally produce: when Gold, containing an admixture of other metals, is melted with Antimony, the Sulphur, having little affinity with its own ſemimetal, forſakes it, and unites with the Silver, Copper, or other metallic bodies mixed with the Gold, but has no action on the Gold itſelf: thus only the impurities of the Gold are combined with the Sulphur of the Antimony, into a ſcoria which flows on the ſurface; whilſt the Gold and the ſemimetal of the Antimony form one compound at the bottom: if this compound be expoſed to a ſtrong fire, and a free draught or blaſt of air, it evaporates in fumes, and leaves the Gold pure behind it. This proceſs ſhews the reſiſt-

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ance of Gold to Sulphur, and to the volatilizing power of the Antimonial ſemimetal, but ſurely gives no foundation for imagining a ſolar Sulphur to exiſt in Antimony.——As Gold is the only metal [Platina excepted] that totally reſiſts Antimony or its Sulphur, this mineral has been called by the chemiſts *Balneum ſolius ſolis*, *balneum regis*, *lupus ultimus judex*, &c.

Precipitation of metallic Reguli in fuſion.

The ſeparation of metallic bodies from Sulphur, by fuſion, is no other than a ſpecies of precipitation, and accordingly is called by ſome dry precipitation; as it depends upon the addition of ſome third ſubſtance, whether metallic or not, to which the Sulphur has a greater affinity than to that metal which it is already combined with: in conſequence of this affinity, the Sulphur in fuſion lets go its metal, to unite with the ſubſtance ſuperadded, and forms with this a light ſcoria, from which the other ſubſides by its own gravity. This is the foundation of all the dry partings of metals: metallic bodies ſeparated by this dry precipitation are commonly called *Reguli*, eſpecially when brittle. The metallic part of Antimony, in particular, is diſtinguiſhed by no other name than that of *Regulus* of Antimony.

Proportion of Regulus and Sulphur.

The proportion of Regulus and Sulphur in crude Antimony, it is difficult, and ſcarce poſſible to exactly determine; as there is always ſome loſs in purifying either the Sulphur from the Regulus, or the Regulus from the Sulphur. There is reaſon to believe, that the Regulus amounts to one half the quantity of the compound, and rather more than leſs.

Methods of ſeparating the Regulus.

The Regulus of Antimony by precipitation is obtained by melting the Antimony with fixt alcaline Salts, Iron, Copper, Tin, *&c.* the Sulphur having a greater affinity with theſe than with the Regulus, and forſaking the latter to unite with the former. The Regulus prepared with alcalies is called *ſimple*; that with metallic bodies is diſtinguiſhed by the name of the particular metal, *martial*, *venereal*, *jovial*, *&c.* All theſe methods are attended with ſome inconveniencies. Alcaline Salts effectually abſorb the Sulphur; but they form with it a *hepar ſulphuris*, which, in fuſion, diſſolves all the metals: hence, in proportion as the Regulus is freed from its Sulphur by the Alcali, a part of it is taken up again by the compound which the Sulphur forms with the Alcali: one third, one half, and often three fourths of the Regulus are thus rediſſolved, and often we find very little Regulus left. Metallic additions are free from this inconvenience, and conſequently occaſion the yield of Regulus to be much larger: but the Regulus thus obtained is never entirely free from ſome portion of the metal ſuperadded. Some have endeavoured to promote the ſeparation of the Regulus by inflammable additions, as powdered Charcoal, Pitch, Reſin, *&c.* but theſe do not at all mend the matter: Antimony, treated with inflammable ſubſtances alone, yields no Regulus; and if alcaline Salts alſo are taken, the inconveniencies will be ſtill the ſame as when thoſe Salts are uſed by themſelves. Many have ſubſtituted to alcaline Salts, crude Tartar or a mixture of Tartar and Nitre, and thought that then they employed no alcalies; not aware, that thoſe are the very Salts from which Alcalies are produced for chemical uſes by the action of fire; and that they do not here effect the intended ſeparation, till the heat has reduced them to that ſtate. There are however ſome differences obſerved in the quantity of Regulus according to the different additions.

Kunckel has given a method of preparing Regulus of Antimony by calcination. He calcines the Antimony till it ceaſes to emit any ſulphureous ſmell, with care to prevent its running into lumps; then mixes the calx with oil or fat and a little powdered charcoal, puts the mixture into a crucible to melt, and, as ſoon as the Regulus begins to ſhew itſelf, injects, by degrees, ſome powdered Nitre, in the proportion of an ounce to a pound of Antimony: the matter in thin fuſion, being poured out, a pure Regulus is obtained, in much greater quantity than by the foregoing methods. There is another, but more expenſive, way of procuring a large yield of pure Regulus; namely, by extracting the Regulus from the Antimony by acid menſtrua, as Aqua regis, or Spirit of Salt; precipitating it from this ſolution; and afterwards reviving the Precipitate, by melting it with inflammable additions.

Chemical properties of the Regulus.

Pure Regulus of Antimony, by whatever means obtained, is a bright ſemimetal, reſembling Tin or duſky Silver; without any thing of the bluiſh caſt of Zinc, or the yellowiſh one of Biſmuth. It is one of the lighteſt of the metallic bodies, [about ſeven times ſpecifically heavier than water] moderately hard, entirely brittle, and of a ſparkling plated texture. In a fire not very ſtrong, it ſmokes copiouſly, and, by degrees, totally evaporates: by a gentler fire, continued for ſome time, it is changed into a whitiſh calx; which, on raiſing the heat, melts into a yellowiſh or reddiſh glaſs. Melted with Silver, or the other malleable metals, it renders them hard and brittle. It deſtroys the magnetic power of Iron; which other metallic bodies only weaken in proportion to their quantity. It does not amalgamate, or not without great difficulty, with Mercury: if a mixture of it with Silver and Copper be reduced into fine powder, even thoſe metals will not, in that ſtate, be acted upon by Mercury (*h*).——In the human body it acts

Medical effects of Antimony in different circumſtances.

(*h*) *Regulus of Antimony with Mercury.*] Common Regulus of Antimony may be amalgamated with Quickſilver, by melting the Regulus, and pouring it, in a ſlender ſtream, into a conſiderable proportion of Mercury made almoſt boiling hot: to prevent any loſs of the Quickſilver, the veſſel may be covered with an iron-plate, and the Regulus poured in through a perforation in the plate. By this method the union ſucceeds more readily and perfectly, than when water is made to boil upon the ſurface of the Quickſilver, as Henckel directs; the Regulus loſing of its heat, in paſſing through the water, before it comes to the Mercury.

A Regulus prepared from Antimony, by the means of Iron and Chalk, unites readily and perfectly with Mercury, by bare trituration with water, into a firm amalgam. This diſcovery was made by Mr. Pott, and communicated in his *Lithogeognoſia*. He obſerves that four parts of Antimony, with one of Chalk, and two or five parts of Iron, yielded Reguli equally amalgamable; and that Marble and Quick-lime ſucceeded equally with Chalk but that Clay, Gypſum, and other earths, had no effect

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as a virulent emetic and cathartic; and impregnates vegetable acids, as Vinegar and acid Wines, with thoſe virtues, almoſt inexhauſtibly. By Sulphur, and by calcination with Nitre, its malignity is abated, and its emetic power changed into a diaphoretic one. As ſoon as it is reſtored to its pure metallic ſtate, it reſumes its virulence; which may be again deſtroyed, and again reſtored, and almoſt infinitely varied.

Hoffman has given an account of the different medicinal effects of Antimony, as depending on its different treatments. He obſerves, (1.) That crude Antimony, on account of the Regulus being corrected by the Sulphur, is not only ſafe, but, in many caſes, a medicine of great ſervice, both for man and other animals. (2.) That, by ſimple fuſion, it acquires a degree of malignity; but a far greater if melted with half its weight of Nitre, which conſumes nearly all the Sulphur, and leaves the Regulus bare. (3.) That Antimony, or its Regulus, mixed with common Salt, calcined over a gentle fire for ſeveral hours, and kept continually ſtirring, and afterwards edulcorated with water, yields an aſh-grey calx, which is ſo fixed as to bear a melting heat, and proves a mild and ſafe diaphoretic, void of any malignant or emetic quality. (4.) That Antimony, by calcination with a gentle fire, in an earthen veſſel, in the open air, changes into a calx, which melts difficultly, and which has no malignity. (5.) That if this calx be melted with a ſtrong fire into glaſs, it becomes ſo ac-

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There is one earthy ſubſtance which produces a very remarkable effect upon Antimony; though neither the earth itſelf, nor the change which the Antimony undergoes, have hitherto been duly examined. The earth, called *cawk*, is found in Lead-mines, in whitiſh, moderately compact, and ponderous maſſes: it is commonly ſuppoſed a ſpar, but differs from the bodies of that claſs in not being acted upon by acids. If a lump of Cawk, of an ounce or two, be thrown red-hot into ſixteen ounces of melted Antimony, the fuſion continued about two minutes, and the fluid matter poured off; "you will have fifteen "ounces, like poliſhed Steel, and as the moſt refined Quickſilver." *Phil. Tranſ.* No. 110. I have ſeveral times repeated this experiment with ſucceſs; but having once varied it by mixing the Cawk and Antimony together at firſt, a part of the Antimony was converted into a dark black vitreous matter, and part ſeemed to have ſuffered little change: on the ſurface of the maſs appeared ſome yellow flowers.

ANTIMONY. tive, that a few grains ſhall occaſion violent vomiting and purging, or even mortal convulſions and inflammations. (6.) That the powdered Regulus, calcined in a glaſs-vial placed in ſand for ſeveral days, becomes a greyiſh diaphoretic powder; which, reduced into Regulus by fuſion with powdered Charcoal, Nitre, and a little fat, proves again virulent. (7.) That when Antimony is melted with one-fourth its weight of Salt of Tartar, the whole poured into a mould, the ſcoria ſeparated, and the more ponderous matter pulverized, the reddiſh powder thus obtained is ſalutary; but that when Antimony is melted with three or four times its weight of Salt of Tartar, both the Scoriæ and the Regulus are virulent. (8.) That equal parts of Antimony and Nitre, melted together, yield a virulent maſs; but one part of Antimony, with two or three of Nitre, an uſeful diaphoretic. (9.) That the Regulus, melted with half its weight of Nitre, continues emetic; but that one part of the Regulus, with two and a half of Nitre, becomes diaphoretic. (10.) That on melting the diaphoretic calces with fat, Charcoal powder and Nitre, the virulent Regulus is revived. And thus one preparation may be changed into another, a ſalutary into a poiſonous, and a poiſonous into a ſalutary one.

Preparations. The preparations of Antimony are extremely numerous. Lemery, in his treatiſe on Antimony, deſcribes no leſs than two hundred; among which there are many good and many uſeleſs ones. That gentleman was an excellent workman, but an unhappy philoſopher: we may depend on his operations, but we are not to truſt his theory. With regard to the Antimonials, the greater number, even of the common preparations, is unneceſſary; many of them differing little from one another, and all of them being either emetic or diaphoretic. For my part, I ſhould be ſatisfied with two, the diaphoretic Antimony and emetic Tartar.

Crude Antimony, as already obſerved, is uſed for purifying the juices, and reſolving obſtructions: it is given likewiſe to cattle, and employed in compoſitions for fireworks, and for the purification of Gold. The preparations of Antimony may be ranged, according to the general operations by which they are produced, under four heads; thoſe obtained by ſolution, by diſtillation, by ſublimation, and by calcination.

Golden Sulphur.

If powdered Antimony be boiled in alcaline Lixivia, or Sope leys; the Sulphur, and, by the mediation of the Sulphur, a part of the Regulus, will be diſſolved into a yellowiſh red liquor. Any acid added to this ſolution precipitates what the alcaline liquor had taken up, in form of a yellowiſh or reddiſh powder; called *Sulphur* or *golden Sulphur* of Antimony: the powder which ſettles at firſt is groſſer and darker coloured than thoſe which follow; it appears of a deep reddiſh brown, whilſt that which ſubſides laſt is of a pale yellow. The firſt is alſo the moſt active.

There are ſundry variations of this proceſs, both in regard to the ſolution and the precipitation. Some employ Lime-water for the menſtruum; others, inſtead of boiling the Antimony in a ſolution of alcaline Salt, melt the Antimony with the Alcali, and boil the ſcoria in water. Some precipitate with one acid, and others with another. Some, that the medicine may with propriety be called *golden*, perform the precipitation with a ſolution of Gold; others take a ſolution of Vitriol of Iron. A difference in the manner of preparing the ſolution does not ſeem to affect the virtue of the medicine, but a difference in the acid uſed for the precipitation does; different acids having very different effects upon Antimony: thus, whilſt the marine renders it highly corroſive, as in the butter of Antimony, and virulently purgative and emetic, as in the Mercurius vitæ precipitated from that butter; the addition of the nitrous deſtroys the virulence of both preparations, and renders the Antimony mildly diaphoretic.

All

ANTIMONY. All the antimonial Sulphurs are emetic and cathartic: thoſe which precipitate firſt are much more ſtrongly ſo, than the powder which falls laſt: the laſt precipitates, if they prove emetic once or twice, ceaſe to have that effect upon their continuing in uſe, and act chiefly as diaphoretics; and hence are greatly to be preferred to the firſt. Theſe preparations are powerful reſolvents, diaphoretics, purifiers of the blood, antiſpaſmodics; of remarkable efficacy in obſtructions of the viſcera, quartan agues, cutaneous and venereal diſorders, ſuffocative catarrhs, leucophlegmatic and cahectic habits. The doſe of thoſe of the laſt precipitation is about ſix grains: two grains may be given to a child of two years or even of one year old.——A powder is vended by the Carthuſian friars in Paris, at a conſiderable price, as a ſpecific againſt ſundry diſorders; commonly called *poudre des chartreux*, but by themſelves *kermes mineral.* This is no other than a golden Sulphur of Antimony, prepared by digeſting powdered Antimony in an alcaline ley, and at length boiling them together; afterwards filtering the liquor, and ſetting it by in a warm place, till a reddiſh brown Precipitate falls ſpontaneouſly.

Kermes mineral.

Butter of Antimony.

For diſſolving the Regulus of Antimony without the Sulphur, the moſt concentrated Spirit of Salt, or Aqua regis, is neceſſary. For obtaining the ſolution in Spirit of Salt; Mercury ſublimate and powdered Antimony are mixed, and digeſted in a glaſs-retort placed in ſand: the marine acid in the Sublimate forſakes the Mercury, and corrodes or diſſolves the antimonial Regulus; whilſt the Mercury of the Sublimate unites with the antimonial Sulphur. But the ſolution of the Regulus, thus effected, cannot be commodiouſly ſeparated from the other matter but by diſtillation: on increaſing the fire, the Regulus ariſes, diſſolved in the concentrated acid not into a liquid form, but into that of a thick unctuous ſubſtance like butter, hence called *butter of Antimony.* The butter liquefies by heat; and requires the cautious application of a live coal, to melt it down from the neck of the retort. By rectification or expoſure to the air, it becomes fluid, but ſtill retains the name of butter: the addition of water, either in its thick or fluid ſtate, by diluting the acid, precipitates the Regulus diſſolved in it. The proportions of Sublimate and Antimony commonly employed are, three parts of the former to one of the latter: it is obſervable, that if Regulus of Antimony in fine powder be mixed with Sublimate in the ſame proportion, and the mixture preſſed down cloſe in a narrow-mouthed glaſs; the matter will, in a little time, grow hot, ſmoke, efferveſce, melt, and boil. There are various other methods of obtaining the butter of Antimony, or a combination of the Regulus of Antimony with marine acid; as, by placing the Regulus in the receiver, and diſtilling over upon it a concentrated marine ſpirit from Sea-ſalt or Sal ammoniac and Oil of Vitriol; or mixing either crude Antimony or the Regulus with common Salt, and diſtilling with the addition of Oil of Vitriol, calcined Vitriol, or ſuch other ſubſtances as may extricate the acid of the Sea-ſalt. If the combinations of Silver or Lead with the marine acid, called *luna cornea* and *ſaturnus corneus*, be mixed with Regulus of Antimony and expoſed to the fire, the acid will forſake thoſe metals, as well as it does Mercury, to unite with the Regulus.

Mercurius vitæ.

There are ſundry preparations made from butter of Antimony, as (1.) *Mercurius vitæ* or *pulvis algarathi*: this is no other than the Precipitate which falls, upon mixing the butter with water. It is a violent and unſafe emetic. A Precipitate obtained from the butter by means of highly rectified Spirit of Wine, is ſaid to be more mild and ſafe, to procure, after its action as an emetic is over, ſleep; and, during the ſleep, to promote a ſweat. Some employ an alcaline ley for the precipitant, and thus alſo obtain a medicine of leſs violent operation. (2.) *Spiritus vitrioli philoſophicus*, improperly ſo called, as it neither contains any thing vitriolic, nor poſſeſſes any ſingular properties that may entitle it to the appellation philoſophic: it is the

Philoſophic Spirit of Vitriol.

Bezoar mineral.

Bezoardic Spirit of Nitre.

the liquor that remains after the foregoing precipitation rectified by diſtillation. (3.) *Bezoar mineral* is prepared, by gradually adding Spirit of Nitre to butter of Antimony placed in a retort, ſo long as any efferveſcence enſues, diſtilling off the Spirit, and calcining the reſiduum: ſome cohobate the ſpirit twice or thrice previous to the calcination, and others employ freſh Spirit of Nitre in each cohobation: this is entirely unneceſſary if the nitrous ſpirit was added at firſt in ſufficient quantity, that is, till it ceaſed to make any efferveſcence with the butter. This preparation may be made more commodiouſly by mixing one part of the *Mercurius vitæ* with two and a half of Nitre, injecting the mixture into a red-hot crucible, and proceeding in the ſame manner as for the calx called diaphoretic Antimony. The Bezoar mineral made in either of theſe ways, proves in no reſpect different from that calx. (4.) The ſpirit diſtilled in making the Bezoar by the firſt of the above methods, is an Aqua regis, commonly diſtinguiſhed by the name of *Spiritus nitri bezoardicus.* (5.) A *lunar bezoardic* is prepared by treating the butter of Antimony with a ſolution of Silver in Aqua fortis inſtead of the acid by itſelf; a *ſolar bezoardic*, by adding a ſolution of Gold to the butter, and then proceeding with Spirit of Nitre as for the ſimple Bezoar mineral; a *martial*, by uſing a ſolution of Iron in the nitrous acid, or mixing Iron with the Regulus previouſly to the diſtillation of the butter; and a *jovial*, by adding Tin to the Regulus. All theſe preparations are very inſignificant.

Clyſſi of Antimony.

The *clyſſi* of Antimony are obtained, by mixing equal parts of Antimony and Nitre, or of Antimony, Nitre, and Sulphur, and injecting the mixture, by a little at a time, into a tubulated retort made red-hot; a large receiver containing this or that diſtilled water, being fitted to the retort: the water, thus impregnated with the nitrous and ſulphureous acid, is to be rectified in a glaſs retort. This liquor has no ſingular qualities to recommend it, and may very well be ſpared: if wanted, it might be procured without uſing any Antimony or Nitre on purpoſe for it, by collecting the vapour which ariſes during the deflagration in making diaphoretic Antimony. If the Nitre is omitted, and the Antimony diſtilled by itſelf, there ariſes a ſouriſh water or weak Spirit of Sulphur, commonly called *acidum antimonii.*

Flowers.

Some make a ſolution of the reguline part of Antimony, by applying the bezoardic Spirit of Nitre to the crude mineral. The ſolution, diluted with water, depoſites a *Mercurius vitæ*, which when prepared in this manner is called *flores antimonii fixiores.* The flowers of Antimony, properly ſo called, are prepared by ſubliming either the crude Antimony or the Regulus into a number of aludels; the fire being kept up ſtrong, and a blaſt of air impelled occaſionally by a pair of bellows upon the matter in the ſubliming pot, to promote its evaporation. We have alſo flowers made by ſubliming, with a gradual fire, a mixture of Regulus of Antimony and Sal ammoniac, grinding the Sublimate with the reſiduum, and repeating the operation till nearly all the Regulus is elevated. We often find three or four kinds of flowers in one ſublimation, differing from one another in their external appearance as well as in quality. In ſubliming the Regulus there are commonly three ſorts; one of a mealy whiteneſs, one ſparkling, and a third of a beautiful chryſtalline appearance: this laſt is called *Silver flowers* of Antimony. Some flowers may likewiſe be collected in detonating the mixture for diaphoretic Antimony in a tubulated retort. The flowers made from crude Antimony with Sal ammoniac, expoſed to the air, run into a liquor called *Oleum febrifugum.* The antimonial flowers are in general of great activity, and though recommended by ſome as Arcana in particular diſorders, require to be uſed with great caution.

Cinnabar.

We have formerly ſeen, that after the diſtillation of butter of Antimony, the Mercury and the Sulphur, contained in the ingredients made uſe of for that proceſs, remain behind in the retort. This compound appears of a black colour: urged with a

ſtronger

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ſtronger fire than that which elevated the butter, it ſublimes into a red maſs called *Cinnabar of Antimony*. This Cinnabar has been by many preferred to the common factitious Cinnabar, but on no juſt foundation: they both conſiſt of Mercury combined with Sulphur; and the only difference betwixt them is, that the antimonial Cinnabar contains ſomewhat more Sulphur than the other, and hence appears of a darker colour. Some have been accuſtomed to ſublime the antimonial Cinnabar a ſecond time, with the addition of a little freſh Mercury, or of ſome calcareous earth to abſorb a part of the Sulphur; and by either of theſe methods they obtain a Cinnabar equal in colour and in every other reſpect to the common ſort. Hoffman has expreſſed himſelf erroneouſly, in ſaying, that the Mercury in Cinnabar of Antimony is fettered by the acid of the Sulphur, and that its revival depends upon the taking away of that acid. It is not the acid, but the whole ſubſtance of the Sulphur, which fetters the Mercury, and which muſt be ſeparated, in order to its revivification, by abſorbent earths, Iron filings, or other abſorbents of Sulphur. A certain writer affirms, that a Cinnabar may be made from Mercury and glaſs of Antimony, and hence infers the exiſtence of ſulphureous particles even in the glaſs. With me the experiment did not ſucceed, though both crude Quickſilver and corroſive Sublimate were tried.

Calcination.

The ſimple calcination of Antimony is performed, by ſpreading the powdered mineral in a flat ſhallow pan, and keeping it over a gentle fire till the ſulphur is diſſipated, and the powder become grey. The powder ſhould be continually ſtirred with a glaſs rod or a tobacco pipe, and if it happens to run into lumps, it muſt be taken from the fire and pulverized afreſh. The heat ſhould be ſlowly and gradually increaſed, and continued till the matter, ſmelt to whilſt red hot, diſcovers no ſulphureous odour. This calx is neceſſary for making the glaſs of Antimony. It may be reduced into Regulus by fuſion with inflammable ſubſtances, and the Regulus into crude Antimony again by fuſion with common Sulphur. It is obſervable that though great part of the Sulphur of the Antimony is diſſipated in this operation, yet the calx weighs more than the Antimony at firſt. Of the matter which exhales, ſo much has been collected as to amount to one eighth of the Antimony.

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Glaſs.

Glaſs of Antimony is chiefly prepared by ſome particular perſons at Amſterdam and Rouen, who have furnaces contrived on purpoſe for calcining large quantities of Antimony with little expence of fuel. The glaſs may be eaſily made, by urging the calx in a crucible with a ſtrong fire, and throwing in, towards the end, a little crude Antimony or Sulphur. I have obſerved, and I know of no one who has made the obſervation before me, that a calx of Antimony, prepared with the utmoſt care, will not yield any Glaſs of itſelf, without the acceſſion of ſome inflammable matter; and that, after reſiſting an intenſe fire of fuſion, it vitrefies immediately upon the injection of a little Sulphur or Antimony, a ſmall portion of Regulus being at the ſame time revived. The glaſs turns out nearly of the ſame reddiſh brown colour, whether Antimony or Sulphur is uſed; but when Borax is taken to promote the vitrification, it proves of a light citron or amber yellow colour. When the vitrification is completed, the Glaſs is poured on a Copper plate or into a Copper diſh, or on a flat ſtone. Some adviſe to ſtir it in the crucible with an Iron rod, but all Iron inſtruments ſhould be avoided; the Iron not only reviving a part of the Regulus, but being itſelf alſo corroded and diſſolved, ſo as to render the Glaſs foul. The glaſs of Antimony is uſed only for making other emetic preparations, as the emetic Wine, Syrup, Sapa, Oxyſaccharum, Aqua vitæ, *&c.* Some employ it for making the emetic Tartar; boiling the powdered Glaſs in water with a proper quantity of Creme of Tartar, and inſpiſſating the filtered liquor. Some digeſt the glaſs, reduced into ſubtile powder, in freſh parcels of diſtilled Vinegar, ANTIMONY. gar, till it no longer gives any tinge to the menſtruum; then inſpiſſate the ſeveral liquors together, and extract a tincture from the reſiduum with Spirit of Wine. The Glaſs has alſo been caſt into drinking veſſels, which communicate an emetic quality to wines that are ſuffered to ſtand in them for any conderable time.

Hepar. Equal parts of crude Antimony and Nitre mixed together, ſet on fire, and ſuffered to deflagrate in an Iron mortar, which may be covered with a perforated plate, or injected by degrees into an ignited crucible, yield a liver-coloured maſs called *hepar antimonii*, which, pulveriſed and edulcorated with water, is named *crocus metallorum*. Two, three, or even one grain of either of theſe preparations occaſion violent anxieties and vomitings; though a dog will bear a drachm, and a horſe a whole ounce, without being apparently any otherwiſe affected than in having the alvine diſcharge increaſed. The emetic Wine, emetic Tartar, and other medicines made from the glaſs, may alſo be made from the Crocus. The Crocus is uſed in ſome places for an eye-water called *Aqua ophthalmica quercetani*.

Emetic Tartar. With regard to emetic Tartar, the practice of cryſtallizing it is very exceptionable; as the cryſtals will by no means be uniform in ſtrength, ſome proving violently and others weakly emetic, and ſome of them being mere cryſtals of Tartar, which have ſhot without any antimonial impregnation at all: the liquor which remains after the cryſtallization, evaporated to dryneſs, yields a maſs very different from the cryſtals. I would therefore recommend, whether Glaſs or Crocus are made uſe of, the ſolution to be gently evaporated to dryneſs; the matter to be kept conſtantly ſtirring, towards the end of the evaporation, as is commonly practiſed in exſiccating ſolutions of fixt alcaline Salts; and the whole of the dry reſiduum to be ground together for a conſiderable time in a ſtone mortar. We ſhould be well ſatisfied of the ſtrength of emetic Tartar before we exhibit it, as there are ſundry variations in its preparation, which vary its effects: the uſe of the Crocus or Glaſs, the manner in which theſe have been made, their proportion to the cryſtals of Tartar, the quantity of water, the length of time that the coction is continued, will all influence the medicine. I have known fatal conſequences from inattention to the differences in emetic Tartars: a Dutch phyſician, who had been accuſtomed to an emetic Tartar prepared with Salt of Tartar, as deſcribed by Morley in the *Collect. chym. Leydens.* whoſe doſe was ten, twelve, fifteen grains and upwards, preſcribed a like doſe of emetic Tartar from a German ſhop, by which the patient vomited to death. I have known alſo three or four grains of ſtrong emetic Tartar prove mortal.

Diaphoretic Antimony.

One part of Antimony, and two and a half or three of Nitre, mixed together and deflagrated, yield a calx void of all emetic power, called *diaphoretic Antimony*. If the detonation is performed in a tubulated retort having a large receiver, containing ſome water, adapted to it; both a clyſſus of Antimony, and antimonial flowers, may be obtained at the ſame time. The calx is to be freed from its ſaline parts by ablution with water: if the water be duly evaporated and ſet to ſhoot, it yields cryſtals called *antimoniated Nitre*; if diſtilled Vinegar is added to the liquor, a white Precipitate falls, called *materia perlata*, or *Magiſtery of Antimony*. Some make uſe of the diaphoretic Antimony without edulcoration; but this practice is not to be approved, the unwaſhed calx containing different ſaline matters, whoſe proportions we cannot be certain of; as the antimoniated Nitre, an alcaline Salt, a vitriolated Nitre produced from the ſulphureous acid and the alcaline baſis of the Nitre. Powdered Regulus of Antimony, deflagrated in the ſame manner with twice or thrice its weight of Nitre, affords a calx not different in quality from the preceding, but diſtinguiſhed by the name of *ceruſſa Antimonii* or *Antimonium diaphoreticum regulinum*. Some think to improve the virtue of theſe calces by burning Spirit of

ANTIMONY. Wine upon them, or diſtilling it off, or treating them with Vinegar: but Spirit of Wine can have no effect, and Vinegar is more likely to deprave than to improve the Medicine. That the calces, as ſome pretend, are a mere earth, not different from pounded tobacco-pipes, is apparently falſe, for we can preſently reduce them, by fuſion with inflammable fluxes, into pure Regulus.

The *martial diaphoretic Antimony* or *ſpecific ſtomachic* of Poterius, is prepared by melting equal parts of Antimony and Iron filings, injecting upon them in fuſion thrice their weight of powdered Nitre, and after the detonation is over, edulcorating and drying the calx. The *jovial diaphoretic Antimony* or *antihectic* of Poterius is made in the ſame manner, from a mixture of Tin and martial Regulus of Antimony, in the proportion of one part of Tin to four of the Regulus. This preparation has no claim to antihectic virtues, nor indeed to any ſalutary operation.

Regulus. The *ſimple Regulus* of Antimony is commonly prepared from equal parts of Antimony, Nitre, and Tartar, mixed together and injected into a red-hot crucible: when the whole is thrown in, the crucible is to be covered, a ſtrong fire kept up for a quarter of an hour, and the matter poured out into a conical mould previouſly warmed and rubbed with greaſe. The yield of Regulus will be larger, if the quantity of Nitre is diminiſhed; or if the Nitre and Tartar are deflagrated together, in the proportion of one part of the former to two of the latter, before their mixture with the Antimony: the Salts are reduced by the deflagration into a black alcaline coal; this is the ſubſtance commonly uſed by the chemiſts for promoting the fuſion of metallic calces, and reviving them into their metallic form, and hence is diſtinguiſhed by the name of *black flux*. Some have been accuſtomed to ſave the expence of Nitre, by taking Pot-aſh or other alcaline Salts: the Regulus is in both caſes the ſame. When the matter is grown cold, the ſcoriæ found on the ſurface are knock'd off, the

Regulus reduced into coarſe powder, melted in a freſh crucible, and about one fourth its weight of purified Nitre injected upon it: this depuration may be twice or thrice repeated with ſmaller proportions of Nitre, till the ſcoria become ſemitranſparent and of an amber colour. The depuration with Nitre is never to be omitted, whether the Regulus is prepared in theſe methods, or in Kunckel's more advantageous way, formerly mentioned, of calcining the Antimony and reviving the calx.

ANTIMONY.

Medicinal Regulus.

The *Regulus Antimonii medicinalis* is improperly ſo called, as being only a reddiſh brown maſs, like the *hepar Antimonii*, without any thing of a reguline or metallic appearance: it is named alſo *febrifugum Craanii*, *panacea antimonii*, *magneſia opalina*, *&c.* There are various formulæ of its preparation. Craan takes five parts of Antimony, four of common Salt, and one of Salt of Tartar; and after melting them together for a quarter of an hour, with a ſtrong fire, pours the whole into a greaſed cone. Some phyſicians in England prepare a medicinal Regulus from Antimony and unpurified common Salt, without the Salt of Tartar; and mix this Regulus with Gum guaiacum, againſt ſcrophulous ſwellings and glandular obſtructions. Hoffman, on the other hand, takes Salt of Tartar without Sea-ſalt, in the proportion of one part of the Alcali to four of the Antimony: and commends the Regulus ſo obtained, as a ſafe and efficacious medicine. The late profeſſor Schulze uſed one part of Nitre to four of Antimony. All theſe preparations, I preſume, may be well ſpared; and indeed they are already almoſt out of faſhion.

Martial Regulus.

The martial Regulus of Antimony is obtained moſt commodiouſly from four parts of powdered Antimony, two parts of Iron nails or wire, and one part of Nitre. The Iron, made red-hot in a crucible, ſoon melts upon adding the Antimony; after which the Nitre is to be injected, the crucible covered, and the matter, when brought into thin fuſion, poured expeditiouſly in a warm greaſed cone. The Regulus, freed from the Scoriæ, is to be melted afreſh, with about one-fourth its weight of Nitre, and this purification, if neceſſary, repeated. If the Regulus retains any ſuperfluous Iron, it will look greyiſh, ſpongy, prove hard to break, and difficult of fuſion: in ſuch caſe, the ſcorification of all the Iron by means of Nitre would be a tedious work; but the addition of a little crude Antimony or common Sulphur will abſorb it at once; and the injection of Nitre will now ſoon complete the purification, and render the Regulus of a ſparkling white colour. Theſe ſcoriæ are yellow and ſemitranſparent like amber: if the quantity of Nitre has not been too large, they prove an exceſſively ſtrong fiery Alcali, diſtinguiſhed by the name of *Nitrum cauſticum.* The yellow ſcoriæ, which ſeparate in the depuration of the ſimple Regulus with Nitre, are likewiſe alcaline, but want the cauſticity of theſe: the ſcoriæ produced from the martial Regulus, by calcination with Tartar, take fire on being expoſed to the air. If either Regulus, after due purification, be haſtily poured into the mould whilſt in exceeding thin fuſion, and if the quantity of ſcoria covering the ſurface is conſiderable, the Regulus, when grown cold, exhibits the appearance of a ſtar upon the top. For producing this appearance, there is no occaſion for any particular ſort of Antimony, or any particular Iron, or any particular conſtellation, or ſeaſon, or weather, as many have idly imagined; the whole depending upon the circumſtances above-mentioned. If the martial Regulus be melted with an equal quantity of purified Copper, the mixture, inſtead of a ſtar, exhibits a net on the ſurface, called *rete vulcani.*——There are ſundry compound Reguli of Antimony, *venereal*, *jovial*, *ſolar*, &c. prepared either by barely melting the Regulus with other metals, or employing the metal in the precipitation of the Regulus at firſt. Different metals abſorb different quantities of Sulphur, and hence require to be taken in different proportions to the Antimony: thus of Iron we take half the weight of the Antimony,

Cauſtic Nitre.

Stellated Regulus.

but of Copper an equal weight, and of Lead twice as much: Tin does not eaſily, in any proportion, precipitate the Regulus. The ſcoria with Tin flow the eaſieſt of all, next thoſe with Silver, then venereal, after theſe the martial; the moſt difficultly fuſible of all are the ſaturnine.——The ſimple Regulus is caſt into cups, which, like thoſe made from the Glaſs, communicate an emetic quality to wines; and into pills, like ſhot, which prove ſtrongly purgative, and do not loſe their virtue in paſſing through the body; whence their name *pilulæ perpetuæ*.

Antimonial tinctures.

There are various tinctures of Antimony, which ſome have fondly imagined to participate of ſolar, venereal, antimonial, and other impregnations. They appear to be all no other than ſimple alcaline tinctures; their colour proceeding from the oily matter of the Spirit of Wine heightened by the cauſtic Alcali. Spirit of Wine conſiſts of an Oil highly attenuated and combined with water into one ſeemingly homogene liquor: if the moſt highly rectified ſpirit, which exhibits no mark of any phlegm, be employed for making theſe tinctures, it will now yield in diſtillation a good quantity of water; the Oil, before combined with that water, having been abſorbed by the Alcali. If cauſtic alcaline Salt alone be poured hot into rectified ſpirit, and the mixture digeſted for ſome time, a tincture will be obtained, not diſtinguiſhable from the antimonial. If Sulphur be added in either caſe, the tincture will receive a conſiderable taſte and ſmell from that ingredient. The common tincture of Antimony is made from the Scoriæ of Antimony; and the *tinctura antimonii acris* or *Regulina*, from the *nitrum cauſticum*. There is nothing remarkable in the preparation; the matter only being put as hot as poſſible into the ſpirit, before it can imbibe any moiſture from the air, and the mixture digeſted till the ſpirit appears ſufficiently tinged.

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Arsenic.

THE chemiſts have formed various conjectures about the nature of this ſingular concrete; but have not been able to determine what it really is, or to what claſs of bodies it belongs. They have called it ſulphureous, unctuous, mercurial, a mineral juice, *&c.* without foundation. Boerhaave, in his *Elementa Chemiæ*, ranks it under the head of Sulphurs, and ſays it approaches nearer to the nature of Sulphur than of any other known mixt: it wants however the peculiar qualities by which Sulphur is diſtinguiſhed. Stahl, with greater probability, ſuppoſes it be of a ſaline nature. In ſome of its ſtates, it apparently poſſeſſes properties attributed to Salts alone; but in other ſtates, it is as obviouſly metallic.

General properties,

White Arſenic, or Arſenic ſtrictly ſo called, is a moderately heavy, compact, hard, brittle concrete; of a cryſtalline or vitreous appearance; gradually changing, from expoſure to the air, to a milky hue like that of Porcelane, and at length to the opake whiteneſs of white enamel. The larger maſſes preſerve their tranſparency longer than the ſmall; in a dry, longer than in a moiſt air.

in the fire,

In the fire, it neither burns nor perfectly melts; but totally and readily exhales, in thick fumes, of a ſtrong fetid ſmell reſembling that of Garlic. The fumes caught in proper veſſels, condenſe, either into cryſtalline maſſes again, or into a white powder; according as the receiver is leſs or more removed from the heat.

metallized by phlogiſton.

Mixed with inflammable matters, and expoſed to the fire in a retort or other like veſſel, it aſſumes a metallic appearance. In this ſtate, it greatly reſembles Regulus of Antimony; being, like that ſemimetal, of a bright ſparkling whitiſh colour, a plated or leafy texture, and very brittle: but its whiteneſs ſoon changes in the air to a dark blackiſh hue. It ſtill continues volatile, as in its unmetallic form: it burns, and calcines in the fire, and ſublimes into white Arſenic as at firſt.

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Solution in water,

Arſenic reduced into fine powder, and boiled in fifteen times its weight of water, totally diſſolves. If the ſolution be evaporated a little, the Arſenic ſhoots, on cooling, into cryſtals; which frequently have a yellowiſh tinge: the entire cryſtals are not taken up again by boiling water, but when finely pulverized, they diſſolve as at firſt. The ſolution has a nauſeous taſte, but not a ſaline ſharpneſs.

in acids and alcalies.

Arſenic diſſolves both in acid and alcaline liquors, but makes no effervеſcence with either: in fixt alcaline Lixivia it diſſolves very plentifully, in acids more ſparingly. Arſenic, in its ſemimetallic form, called Regulus, is eaſier of ſolution than the white Arſenic or calx.

Phænomena with different acids.

Powdered white Arſenic being digeſted with Oil of Vitriol, and the liquor diſtilled off in a retort; there aroſe at laſt a tranſparent Sublimate like pure Glaſs, but which loſt its tranſparency in a few days in the air, and became opake like the Arſenic by itſelf. If the fixation of Arſenic is applicable to any uſeful purpoſes, the preſent experiment promiſes means of effecting it: for the Arſenic remaining in the retort after the ſublimation, ſuſtained an open fire without ſuffering any ſenſible alteration; and probably it might be rendered ſtill more fixed by repeating the abſtraction of freſh Oil of Vitriol.

One part of white Arſenic being diſſolved in two of Oil of Vitriol, and one part of Borax added to the mixture, a ſtrong effervеſcence enſued, and whilſt the matter continued hot, ſome fine capillary flowers as it were, like flowers of Borax, appeared upon the upper part of the Glaſs. By degrees, the liquor grew more and more clear and tranſparent; but on cooling, acquired the colour and conſiſtence of Venice Turpentine. The maſs liquefied, in the ſame manner as Turpentine, on applying heat; but the air ſoon rendered it white, turbid, and untranſparent.

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Two drachms of Arſenic being boiled in two ounces of good Spirit of Nitre, till the greateſt part of the Spirit had exhaled; and two ounces more of the acid being then added, and the whole well ſtirred together, the Arſenic totally diſſolved. The ſolution, evaporated a little and ſet to cool, yielded ſeveral ſmall quadrangular cryſtals; and the uncryſtallized liquor looked like a pretty thick ſolution of gum Arabic. Henckel obſerves, in his *Pyritologia*, that Arſenic forms a gum-like ſubſtance with Spirit of Nitre; but does not mention the proceſs. It was in conſequence of this hint that I made the two preceding experiments.

With various ſaline liquors, and metallic ſolutions.

A ſolution of Arſenic in pure water changed Syrup of Violets green, but not till they had ſtood together for ſeveral hours. It made no effervefcence with any ſaline liquors, acid or alcaline. Nor did I obſerve that any precipitation enſued, as a certain learned author ſays there does, upon mixing with it Oil of Tartar per deliquium, Oil of Vitriol, or Aqua fortis. Oil of Tartar ſcarce occaſioned any ſenſible cloud; but Spirit of Sal ammoniac threw down a little precipitate. There was no precipitation or change upon mixing it with ſolutions of vitriolated Tartar, purified Nitre, common Salt, Sal mirabile, Alum, Borax, Sal ammoniac, and the ſaline concrete called fixt Sal ammoniac. It precipitated almoſt all metallic ſolutions, but ſome of them ſo ſlowly, that an incurious or haſty obſerver would have pronounced there would be no precipitation. Solution of Gold ſuffered no change at firſt from the admixture of the arſenical ſolution; but, on ſtanding for twenty-four hours, it let fall a yellow Precipitate, like Aurum fulminans. Solution of Silver grew immediately turbid and bluiſh; and, in twenty-four hours, depoſited a dark browniſh grey Precipitate. A ſolution of Iron in Aqua fortis continued at firſt clear; but, on ſtanding for twelve hours, a ſmall quantity of ſubtile yellow powder ſubſided. A ſolution of Copper in Aqua fortis gave a whitiſh calx; and the bluiſh liquor ſtanding above it turned at laſt green. Solution of Tin in Aqua fortis was very copiouſly precipitated. Solution of Lead in Aqua fortis ſuffered no change at firſt, but on ſtanding yielded a plentiful Precipitate. Solution of Mercury in Aqua fortis let fall a plentiful flaky Precipitate; on the ſurface of which were obſerved, next morning, ſome particles inclining to yellow. Solution of Mercury-ſublimate, of Copper in Aqua regia, of Zinc in Aqua fortis, and of Regulus of Antimony, continued clear and ſuffered no precipitation. Biſmuth diſſolved in Aqua fortis is copiouſly precipitated by a large addition of the arſenical liquor, but not at all by a ſmall one. Solution of white Vitriol yields a yellow powder; of green Vitriol, a thick yellow Precipitate; but that of blue Vitriol depoſites very little. Solution of Sugar of Lead, and ſolutions of Sulphur, made both with Quicklime and with fixt alcaline Salts, are copiouſly precipitated by the arſenical liquor: the ſulphureous ſolutions are precipitated even by a tincture made from Arſenic with highly rectified Spirit of Wine: from whence it appears that vinous ſpirits diſſolve ſome portion of this concrete. The *liquor ſilicum*, mixed with the watery ſolution of Arſenic, coagulates on ſtanding. I likewiſe diſſolved Arſenic in Oil of Vitriol, Spirit of Nitre, Spirit of Salt, Oil of Tartar per deliquium, and Spirit of Sal ammoniac; and mixed the acid ſolutions with alcalies, and the alcaline ſolutions with acids. No precipitation enſued in any of theſe mixtures, except two; namely, when Oil of Tartar was dropt into the ſolution made by Spirit of Salt, or Spirit of Salt into that made by Oil of Tartar; in both theſe caſes a precipitation happened on ſtanding, moſt readily and plentifully in the laſt.

With Mercury-ſublimate,

If the Arſenic be mixed with Mercury-ſublimate, and the mixture expoſed to the fire in a retort, the Sublimate will be deſtroyed, or reſolved into its conſtituent parts. Its acid quits the Mercury, and unites with the Arſenic; and there diſtils a butter or Oil of Arſenic, that is a ſolution of the Arſenic in the marine acid; followed by the revived Mercury. We

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may judge from hence how little foundation there is for the common report that Mercury-ſublimate is adulterated with Arſenic: it is plain that they cannot be united together by ſublimation, and Arſenic cannot be mixed afterwards with the maſs, as we always meet with it in cakes. The method propoſed for detecting the abuſe, if the abuſe ſhould be practicable, is likewiſe erroneous: it is ſuppoſed, that Sublimate mixed with Arſenic will turn black with alcaline Lixivia, and pure Sublimate not: but Arſenic by itſelf ſtrikes no blackneſs with alcalies, and ſome pure mercurial Sublimates do, probably from their being ſuperſaturated with Mercury.

With Nitre.

White Arſenic makes no deflagration with Nitre; but extricates the acid of the Salt in a remarkable manner. If two parts of Nitre and one of Arſenic be committed to diſtillation in a retort, and ſome water placed in the receiver to promote the condenſation of the fumes; a nitrous ſpirit will be obtained, far more volatile, ſubtile, and penetrating than common Spirit of Nitre, and of a beautiful blue colour. This ſpirit requires to be kept in veſſels very cloſely ſtopt: if the air is admitted, its volatile vapours ſoon eſcape, and all its colour vaniſhes (*i*). A part of the

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(*i*) *Arſenic with Nitre.*] Regulus of Arſenic deflagrates ſtrongly with Nitre: the Calx or white Arſenic does not ſenſibly deflagrate, but makes a conſiderable ebullition, and if the operation is performed in open veſſels, alcalizes the Salt. A large portion of the Arſenic remains united with the Alcali, into a ſaline concrete; which deliquiates in the air, and diſſolves in water into a viſcous liquor, excepting a little flaky matter, which reſiſts both liquid menſtrua and fire. The arſenicated Alcali melts eaſily into a kind of pellucid glaſs; which, continued in the fire, emits copious fumes, and becomes more and more opake, and milky, and difficult of fuſion.——The ſame kind of arſenicated Salt is obtainable by combining white Arſenic with the common fixed alcalies.

When Arſenic and Nitre are diſtilled in cloſe veſſels, the Arſenic remains combined with the Alcali of the Nitre, into the appearance of a perfect neutral Salt; which diſſolves in water, does not liquefy in the air, ſhoots into regular cryſtals, makes no change in the colour of Syrup of Violets, nor any efferveſcence with alcalies or acids. It nevertheleſs precipitates moſt metallic ſolutions made in acids, its Alcali uniting with the acid, and its Arſenic with the metal. Urged with a ſtrong fire in cloſe veſſels, it ſuffers no change: even the addition of vitriolic acid does not diſunite the Arſenic from the Alcali. Laid on burning coals, its compoſition is inſtantly reſolved; the Arſenic reviving and evaporating.

the Arſenic ariſes diſſolved in the ſpirit, as appears from the liquor making Copper white: what remains, along with the alcaline baſis of the Nitre, proves conſiderably more fixed in the fire than Arſenic by itſelf.

With alcalies and vitreous matters.

Arſenic is detained alſo in the fire by common alcalies and earths, and may be converted along with them into a true Glaſs: thus, if Arſenic be diſſolved by boiling in a ſolution of alcaline Salt, the liquor inſpiſſated, the dry matter mixed with powdered Flint, and urged with a ſtrong fire as for making common Glaſs, they will all vitrify together. Lemery relates, that in divers operations upon Arſenic in glaſs veſſels, there is often met with a vitrified matter, not diſtinguiſhable from the common Glaſs of which the veſſel is made, except by its being a good deal more brittle. I have often obſerved ſuch a ſubſtance myſelf; but it was only a clear cryſtalline Arſenic, and not a true Glaſs.

With metals.

Arſenic unites in fuſion with all the metals; commonly promotes their fuſibility, and renders them hard and brittle; and changes the coloured ones white. In a ſtrong fire, a part of the Arſenic evaporating, generally carries off a part of the metal, eſpecially of the imperfect metals; and the remainder of the metal, calcining, vitrifies with the Arſenic. Lead forms with Arſenic a hyacinth coloured Glaſs, which proves a more

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The arſenical Calx is found likewiſe to expel the nitrous acid from its combination with the baſis of Sea-ſalt, with common fixt alcalies, with volatile alcalies, and with abſorbent earths; though incapable of expelling the weaker acid of Sea-ſalt from any of theſe. After the expulſion of the nitrous ſpirit, the Arſenic remains always combined with the Alcali or earth into a neutral ſaline concrete: it may even be transferred from one into another, from volatile alcalies into abſorbent earths. The Arſenic is not to be diſunited from the earths, any more than from fixed alcalies, by the ſtrongeſt fire in cloſe veſſels, but readily exhales in open ones on the contact of inflammable matter. Hence certain ores, which emit no arſenical fumes by ſtrong calcination per ſe in the common method, on the addition of a little charcoal, yield abundance.

The foregoing obſervations are drawn from a curious ſet of experiments, by Mr. Macquer, in the French Memoirs for the years 1746 and 1748.

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a more powerful flux for earthy, and other refractory bodies, than the pure glaſs of Lead.

Iron may be combined with Arſenic, by mixing the Arſenic with fixt alcaline Salt and ſome inflammable matter, as Sope, powdered Charcoal, Tartar, *&c.* ſtratifying this mixture in a crucible with thin Iron plates or Iron filings, fitting on the veſſel a cover with a ſmall hole in it, giving at firſt a gentle fire, ſuch as the Arſenic by itſelf could bear, and then raiſing the fire as expeditiouſly as poſſible, till the matter is brought into fuſion; or by mixing Arſenic, Tartar, and Iron filings together, injecting them into a crucible ſtrongly heated, and pouring out the matter as ſoon as it appears fluid. Thus we obtain an arſenicated Iron, hard, brittle, and whitiſh.

Copper, combined in like manner with Arſenic, becomes white; and retains ſome degree of malleability, eſpecially if the proportion of Arſenic is not too large, or if the compound is melted once or twice with Tartar and Borax. An over-proportion of Arſenic makes the Copper not only brittle, but of a dark colour, or liable to turn black on expoſure for a few days to the air. The workmen have different methods of preparing white Copper for mechanic uſes. Some take equal parts of Copper and Arſenic, with a little Silver, as one part of Silver, precipitated from Aqua fortis after quartation, to ſixteen of the Copper; ſtratify them together, cement in a cloſe crucible, and then raiſe the fire to fuſion. Some barely melt the Copper with Arſenic fixed by Nitre. Some, inſtead of white Arſenic, take yellow or ſulphurated Arſenic, (of which hereafter) and ſublime it from a good quantity of common Salt: of this Sublimate they inject a little upon melted Copper, which generally receives from thence a very beautiful white colour. Some ſtratify and melt the Copper with fixed Arſenic and a little Luna cornea; others add a Zinc; and the more expert artiſts, inſtead of Copper, uſe Braſs. Theſe white metals are made into buckles, candleſticks, and different kinds of ornamental furniture; but are never to be uſed for any veſſels deſigned for containing foods or liquors.

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Arſenic debaſes the colour of Silver, renders the metal brittle, and in part volatilizes it. Silver melted in a cloſe veſſel with Arſenic and a little Sulphur, forms a red compound, in ſome meaſure reſembling the Silver ore. The arſenical Sublimate obtained from that ore, ſtrongly heated in a cloſe Silver box, penetrates the metal, and renders it quite porous. Silver cemented with pure Arſenic, remained brittle and pulverable after the Arſenic hath been diſſipated by gentle calcination.

Tin melted with Arſenic is ſoon changed in part into calx; and both the calx and the uncalcined part retain no ſmall proportion of the Arſenic. The Tin, thus arſenicated, appears of a ſparkling white colour, and plated texture, greatly reſembling Zinc. Hence ſome have imagined it to be a true Zinc; though the intrinſic properties of this compound are entirely different from thoſe of that ſemimetal.

Lead melted with Arſenic, begins to boil and ſmoke in a leſs degree of heat than is neceſſary for producing that effect upon pure Lead. A part of the Lead evaporates, part runs into a fuſible ſaffron yellow glaſs, and what retains its metallic form proves brittle and of a dark duſky colour.

Gold itſelf is not only rendered brittle and deprived of its colour by Arſenic, but volatilized. If the mixture be haſtily urged with a ſtrong fire, a part of the Gold ſublimes.

Affinities with metals.

Arſenic has different degrees of affinity with different metals. It forſakes Silver to unite with Lead, and hence in running down the arſenical Silver ores, the workmen commonly add a large proportion of Lead to abſorb the Arſenic. In like manner it quits Lead for Tin, Tin for Copper, and Copper for Iron. White Copper melted with Iron filings, recovers its original redneſs, the Arſenic being transferred into the Iron. Copper has a greater affinity with Mercury than it has with Arſenic. Mercury amalgamated with

ARSENIC white Copper, takes up only the pure Copper, the Arſenic being rejected to the ſurface. Arſenic is more eaſily ſeparable from all the metals than Sulphur is: though Sulphur is not rapacious, or apt to volatilize them, like Arſenic, it adheres to them much more ſtrongly.

Uſes. Arſenic is employed for ſundry mechanic uſes; by the dyers, as an ingredient in the compoſitions of ſcarlet and other fine reds; by the girdlers and pin-makers, for whitening their Braſs or Copper; by the goldſmiths, for enamelling; by the glaſs-makers, for promoting the fuſion of the fritt, and the clearneſs and tranſparency of the glaſs; by the porcelane-makers, in white glazings; by the preparers of compound metals, for communicating a Silver whiteneſs to Copper; by the aſſayers it is uſed in the form of glaſs, for promoting the ſcorification of refractory ores which participate of Tin and Antimony, and which will not work off but run into lumps in the cupel. I know an artiſt who prepares a beautiful metal, like the fineſt Steel, by melting caſt Iron with Arſenic and Glaſs, and adding a little Tin during the fuſion. The beauty of the metal depends in great meaſure upon the proportions. In Vienna, a metal is made for ornamental uſes, reſembling the fineſt Silver, from Iron, Tin, and Arſenic; perhaps with the addition of a little Copper. Arſenic is uſed alſo in ſolders, or for uniting Iron with Tin, in ſome places in the making of tinned Iron plates.

Arſenical compound metals.

Medical hiſtory. Arſenic is a moſt violent poiſon to all animals; unleſs the wolf ſhould be an exception, who is ſaid, probably without ſufficient foundation, to be only purged by it. The utmoſt caution is neceſſary, in all operations upon Arſenic, to avoid its fumes. It is on account of the danger attending ſuch operations that this mineral has hitherto been ſo little examined by the chemiſts. The deſtroying of rats, mice, or other domeſtic animals, by means of Arſenic, is full of danger; the operation of the poiſon being ſuch, that great part of it is diſcharged, and the animal induced to drink. Hence foods, liquors, and the provender of cattle, have too often received a poiſonous taint. If we cannot catch thoſe animals, we may nevertheleſs be cleared from them by much ſafer means than the uſe of Arſenic. Freſh nightſhade is their enemy. If the juice of the leaves or berries of that plant, or the diſtilled water of the freſh herb, be made into pellets with meal; the rats, without taſting the pellets, will forſake the places where they are laid.

With regard to the effects of Arſenic in the human body; a nauſea, ſickneſs and reaching commonly enſue in about half an hour after taking it; followed by violent vomitings, hiccups, and pains in the ſtomach and bowels. Convulſions and palſies of the limbs preſently ſucceed, with intenſe heats, cold ſweats, palpitations of the heart, extreme anxiety, reſtleſſneſs, proſtration of ſtrength, thirſt and dryneſs of the mouth and throat, loſs of reaſon, and at laſt death. If the quantity taken has been conſiderable, the ſtomach and inteſtines are often found upon diſſection corroded or perforated; though in general the patient expires, before the action of the poiſon has proceeded to ſuch a length. There are many poiſons which act by coagulating the juices; but the operation of Arſenic is erroneouſly ſuppoſed to be of this kind. Arſenic rather liquefies than coagulates the blood, and makes no change in its colour, Of milk, ſaliva, and other animal juices, it rather prevents than promotes the coagulation. ' It is better to acknowledge our ignorance, than to advance groundleſs conjectures.

Antidotes.

Several ſubſtances have been propoſed as antidotes to this poiſon. Thoſe who imagine Arſenic to be an Alcali, recommend acids; and thoſe who imagine it a corroſive acid, direct alcalies for counteracting its effects: but Arſenic is apparently neither one or the other. If rock Cryſtal, or Bezoar, or the roots of the eldertree, by ſome ſtrongly recommended, have ſeemed to do

ARSENIC do ſervice where Arſenic has been taken; it was not on thoſe ingredients, but on the oils or fats uſed along with them, that the good effects of the medicine depended. Oils, fats, warm fat broths, freſh butter, milk taken plentifully and repeatedly, are the only antidotes; both for obtunding the force of the Arſenic, and promoting its diſcharge by vomit. If the vomiting does not freely ſucceed by the liberal uſe of theſe kinds of ſubſtances, ſome mild emetic muſt be called in aid; the expulſion of the poiſon being a principal point. The more threatning ſymptoms being thus removed, oily glyſters, and a gentle laxative are neceſſary, to obtund and evacuate ſuch part of the Arſenic as may have paſſed into the inteſtines; after which the ſtrength is to be recruited by proper analeptics.

Chemiſtry is capable of converting ſundry poiſons into medicines. Thus the virulent antimonial Regulus is changed by that art into the mild diaphoretic Antimony; the violently corroſive Sublimate of Mercury, into the mild Mercurius dulcis. Some have been hence induced to imagine, that Arſenic alſo might be corrected and rendered ſafe; and have even ventured to put ſo dangerous a ſpeculation in practice. A preparation of Arſenic with Nitre has been actually ſold by certain people about Berlin and in other places, under the title of a ſpecific febrifuge. But Arſenic, however prepared, continues Arſenic ſtill. We can mitigate and obtund, but we cannot deſtroy its power. See Stahl's *Menſis novembris*, entitled *Anchiater ſive venenum pro remedio venditum.*

Effects when externally applied.

There are many examples of even the external application of Arſenic, producing dangerous conſequences. Thus Hildanus mentions great debility, a high fever, delirium, anxiety, palpitation of the heart and tremor of the limbs, from ſcarcely a grain of Arſenic applied to an ulcer in the foot. Some arſenical preparations have nevertheleſs been recommended againſt cancers and cancerous ſores. And Arſenic itſelf has been worn on the pit of the ſtomach in times of the plague, as if one poiſon was to be driven out by another. The celebrated Dr. Mead has ſhewn, that the uſe of Arſenic as an antipeſtilential, proceeded from an erroneous opinion of its being the ſame with the ſubſtance recommended in that intention by the Arabians, under the name of *darſini.* The *darſini* of the Arabians was no other than Cinnamon, though ſuppoſed, from the affinity in ſound, to have been Arſenic.

Marks for diſtinguiſhing it.

Caſes frequently happen, in which we are called upon to determine whether a particular ſubſtance be Arſenic or not; as when powdery matters are found in the ſtomach of thoſe who are ſuſpected to have died by poiſon. Arſenic, in a ſolid form, may be diſtinguiſhed by its yielding, in the fire, white fumes and a garlic ſmell; and by its whitening Copper. This laſt trial is moſt commodiouſly made, by placing a little of the powder betwixt two clean, poliſhed copper-plates, binding the plates firmly together with wire, cloſing the juncture all round with a good lute, and then heating them red-hot. We may try alſo whether any reguline or ſemimetallic matter is obtainable, by means of Tartar and Suet. Arſenic diſſolved in liquors is much more difficultly diſcovered; and I can ſcarce propoſe any thing in this view, beſides the experiments on ſolution of Arſenic formerly related. But I forbear to ſay any thing further on this head, leſt, in endeavouring to diſcover Arſenic, I ſhould furniſh means for rendering it leſs eaſily diſcoverable.

Preparations.

The principal preparations of Arſenic are, fixed Arſenic and the arſenical magnet. Fixed Arſenic is made by gradually injecting powdered Arſenic into melted Nitre, commonly in the proportion of one part of the former to two of the latter. When the ebullition is over, the crucible is covered, the matter kept melted for a little time with a ſtrong fire, and afterwards edulcorated with water. The arſenical magnet is a mixture of equal parts of pure white Arſenic, Sulphur, and Antimony, reduced ſeparately into fine powder, then mixed, put into a glaſs body ſet in ſand in a crucible, and urged with a very gradual fire, till the matter is melted into a red vitreous maſs reſembling a deep garnet or ruby. We muſt be cautious in handling this arſenical glaſs, as a wound received from it may be dangerous.

Natural Hiſtory.

Pure cryſtalline white Arſenic is never found native in the earth. A powdery white Arſenic is now and then met with in ſome of the Bohemian and Saxon mines; though even this ſeems to be not a natural Arſenic, but to have been ſeparated and ſublimed from the ores, by the wood fires made in the mines for burſting the maſſes of ore. It is obſervable, that Saxony, of all countries in the world, is the richeſt in arſenical ores; and that the richeſt Silver ores abound with Arſenic.

Some of the proper ores of Arſenic are of a whitiſh, and others of a blackiſh colour, and both ſorts have more or leſs of a ſparkling metallic aſpect. The firſt are called white Pyritæ, or *miſſpickel*; the latter *ſtiegenſteinertz*. They conſiſt moſtly of Arſenic, blended with a conſiderable proportion of earthy or ſtony matter, but with little if any mixture of any other metallic body.

Preparation of white Arſenic.

The preparation of Arſenic was diſcovered only about two centuries ago. The ancients were unacquainted with our Arſenic; their αρσενικον or αρρενικον being our orpiment. The greateſt quantities are prepared at Geyerſberg, near the village Ehrenfriederſdorf, in Miſnia, from ores brought thither from Schneeberg and other Saxon mines. The ore is thrown into a furnace reſembling a baking oven; whoſe flew is an horizontal pipe, near an hundred fathoms in length, of conſiderable width at the end where it communicates with the furnace, and growing gradually narrower to the other end. The ore is every now and then ſtirred and turned in the furnace, to promote the extrication of the Arſenic; which ariſes in fumes into the pipe, and there conpenſes into a greyiſh or blackiſh powder called *Meal Arſenic*. The meal Arſenic is refined by a ſecond ſublimation in cloſe veſſels, with the addition of a little Pot-aſh, which detains its impurities. In this operation, the fire which elevates the Arſenic heating the receiver, the flowers melt together into the cryſtalline maſſes brought to us. The whiteſt and pureſt Arſenic, ſublimed with a little Oil, from Iron filings, or from any inflammable matter, becomes grey or blackiſh like the crude meal; and becomes white again by a reſublimation from Pot-aſh. Henckel obſerves, that Quickſilver alſo detains this inflammable or colouring matter, and does it more effectually than any other ſubſtance. — The ores, particularly the black ſort, ſublimed in cloſe veſſels, without addition, yield a light porous, foliaceous, Regulus of Arſenic. ARSENIC

Arſenic in ores.

The red Silver ores, ſeveral of the Copper-ores, and moſt of the ores of Tin, abound with Arſenic; which evaporating during the fuſion of the ore, in part condenſes about the top of the furnace, and forms ſublimates of various colours, white, grey, yellowiſh, *&c.* according to the admixture of Sulphur or other matters. The Arſenic carries off in its exhalation ſome portion of the metal. At Andreaſberg, the arſenical vapours which ariſe in the working of Silver ores, are caught in a proper reſervoir, and ſome Silver recovered from the Sublimate.

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There is a ſingular ore of Arſenic called Cobalt, *Cobaltum pro cæruleo*, *Cadmia metallica*, *Blaufarben kobold*. This appears of a whitiſh colour, ſomewhat darker than the white Arſenic ores ſtrictly ſo called, and differs from them remarkably in ſome of its properties; yielding, after the diſſipation of its Arſenic, the blue Glaſs called *Smalt*, and the ſubſtance commonly uſed for tinging Glaſs blue under the name of *Zaffre*, *Zaffera*, *Zaffloer*, &c. This ore is moſt plentiful in Saxony, particularly near Schneeberg in the diſtrict of Miſnia. It is found alſo in ſeveral other

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parts of Europe. At St. Andreaſberg in the Upper Hartz, large quantities have been met with for upwards of twenty years; but the manufacture of Zaffre and Smalt is confined to Saxony alone, no method having been found elſewhere of making the colour ſucceed. Saxony has long ſupplied all the other parts of the world with theſe commodities, and exports them even to the Eaſt-Indies. The general method of preparing them is deſcribed by Kunckel; but there are ſome particular managements in the operation, which the workmen are bound by an oath not to reveal; and a prohibition is laid on the exportation of unmanufactured Cobalt (*k*).

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(*k*) *Cobalt.*] This mineral, in its purer ſtates, is conſiderably compact and heavy, and not unfrequently of a ſemimetallic appearance. Its texture is always fine; ſometimes granulated, or compoſed of minute grains ranged into ſmall ſtriæ; ſometimes ſmooth and even, without any diſtinguiſhable grain. Its colour is ſometimes a pale iron grey, ſometimes a darker bluiſh or blackiſh grey. From variations in the appearance of the mineral itſelf, or from its different admixtures, ſome of the mineralogiſts have divided it into diſtinct ſpecies, the principal of which are theſe. (1.) Dark grey Cobalt: compact, ponderous, and of a very fine grain. This ſort is ſaid to be the moſt eſteemed at the Saxon works, and to afford the fineſt blue glaſs. (2.) Bright pale grey or aſh-coloured Cobalt; of a ſomewhat looſer ſtructure, and leſs ponderous. This kind has a great reſemblance to the arſenical Pyritæ, and ſome of the white Silver and Copper ores; from which thoſe who are accuſtomed to the inſpection of theſe minerals diſtinguiſh it, pretty readily, by the colour of the Cobalt being ſomewhat duller, and its texture finer. (3.) Vitreous Cobalt; in ſtructure reſembling melted ſcoria or glaſs, of a bright bluiſh grey colour; called by the Germans *Schlackenkobold*, ſlag Cobalt. (4.) Cryſtalliform Cobalt; affecting chiefly a cubical figure, ſometimes perfect, but commonly with the angles imperfect. (5.) Specular Cobalt; intermixed with glittering talky flakes. (6.) Earthy Cobalt; blended with various earths into ſoft friable compounds, of a black, yellowiſh, grey, or other colours. (7.) Flowers of Cobalt. Theſe are of a looſe radiated ſtructure, and generally not ſo heavy as the foregoing ores. The external parts are of a fine purpliſh red, a violet, or a peach bloom colour. Sometimes the whole maſs is elegantly tinged with theſe colours throughout, but more commonly the internal parts are of a greyiſh or leaden hue. They are never found in great quantities, or forming regular veins; but only in detached maſſes, lodged in clefts of ſtones, in places to which the air has had free acceſs. They appear to proceed from a ſpontaneous reſolution of ſome of the foregoing minerals; moſt of which are found upon experiment to yield nearly ſimilar effloreſcences on being expoſed in heaps for a length of time to a moiſt air. Wherever the workmen meet with theſe flowers, they expect a rich vein of Cobalt in the neighbourhood.

The ore is firſt reduced into powder in ſtamping-mills; then calcined, and the Arſenic collected, in the manner above deſcribed. There maining mineralis pulverized and calcined afreſh, and this repeated perhaps a third time, that the Arſenic may be completely expelled. After the laſt calcination, it is paſſed through a fine ſieve, which is moved by a mill: what will not paſs, is ground and calcined again. The powder thus prepared is fit for making either Zaffre or Smalt.

Zaffre.

For Zaffre, a quantity of Flints, or of the flinty ſtones found adhering to ores, and called by the miners *quartz*, is reduced into a fine powder, and ſifted. One part of the calcined cobalt is mixed with two, three, or more parts of the powdered Flint, according as the Zaffre is intended to be of the beſt or of an inferior kind. This mixture is moiſtened with water, and preſſed cloſe into wooden caſks for exportation. On ſtanding, it acquires by degrees a ſtony hardneſs; though, if no water is added, it continues powdery or crumbly. It is uſed for tinging Glaſs of various ſhades of blue; and for the blue glazing of

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The Cobalt mines of Schneeberg are ſaid to be two or three hundred fathoms deep; and the Cobalt lodged at great depths to be of a better quality than that which is near the ſurface. The Schneeberg hill, according to the ancient chronicles of Saxony, yielded at firſt only an Iron ore; which on ſinking deeper, about the beginning of the fourteenth century, was ſucceeded by a very rich ore of Silver. This alſo, being at length exhauſted, gave place to Cobalts. Some pieces of the Cobalt ores are ſtill found to participate of Silver, and even of Gold. Schluter relates, that he has ſometimes obtained after the proportion of three ounces of Gold and upwards upon the hundred pounds. Theſe metals however, far from being eſſential, as ſome have raſhly ſuppoſed, to all Cobalts, are entirely accidental even to this: nor are they equally diffuſed through thoſe maſſes in which they happen to be lodged: different pieces containing different proportions, and ſome none at all.

Cobalt has been met with in ſome parts of England; at Mendip hills in Somerſetſhire, and in Cornwall; in which laſt county it has of late been dug in conſiderable quantity, though not entirely agreeing in quality to the accounts given by authors of the ſorts which are manufactured in Saxony. It is ſuppoſed that the Chineſe, and more particularly the Japoneſe, had formerly mines of an excellent Cobalt, with which were painted the fine blues of their ancient porcelanes; but that theſe mines are now exhauſted, and that the inferior blues of their preſent ware are painted with the Saxon Zaffre imported to them by the Dutch.

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earthen ware. I have known Lapis lazuli imitated with it.

Smalt.

Smalt is made by mixing the calcined Cobalt with a certain proportion of ſand and Pot-aſh, the common ingredients of Glaſs, and vitrifying the mixture with a ſtrong fire. After the fuſion, a metallic matter, called Regulus of Cobalt, is commonly found at the bottom. This is employed in ſubſequent vitrifications. The whiter the ſand, and the purer the Pot-aſh, the finer will be the colour of the Glaſs; and the ſmaller the proportion of theſe ingredients, the deeper the colour: hence the different ſortments of Smalt, common, good, fine, and ſuperfine. The Glaſs of each kind is ſtamped in mills, ground betwixt two hard ſtones, waſhed, further ſorted, dried, and packed up (*l*).

White

(*l*) *Zaffre and Smalt.*] The preparation of theſe concretes was long kept an entire ſecret, and their origin in general unknown. Many have ſuppoſed Zaffre to be a native earth or ſtone; and even the learned Dr. Merret, after rejecting this opinion, endeavours to eſtabliſh a no leſs erroneous one, that it is a compound of Braſs, Calamine, and Sand. Libavius however, ſo early as the year 1506, gave ſome account of its true production. He ſays that, after the eliquation of Biſmuth from its ore, *recrementa in lignis & fovea ſubſiſtunt . . . . quæ . . . . reverberii furno exercitata, in lazurium figulorum vitrariorumque & ſimilium tranſmutantur, titulo zapharæ.* Kunckel was the firſt who gave any circumſtantial detail of the method of preparing theſe ſubſtances; and to his account ſome later writers have added further particulars. As attempts are making to introduce this manufacture into England, it may be proper to collect into one view all the information we can procure from them in regard to the management of the proceſs in Saxony.

The Cobalt taken out of the mine, is broken with hammers into pieces about the ſize of a hen's egg; and the ſtony involucrum, with ſuch other heterogeneous matters as are diſtinguiſhable by the eye, as much as poſſible ſeparated. In this ſtate, it is aſſayed, valued, taxed, tithed, and delivered to the manufactures. —— In digging the mines, the workmen frequently meet with hard ſandy maſſes cutting and interrupting the vein. Theſe are broken in mills; and the Cobalt, that had been imbedded in them, ſeparated by ſieves.

The mineral, brought to the manufactures, is pounded in ſtamping-mills, and ſifted through braſs-wire ſieves. According to ſome, the lighter earthy parts are waſhed off by water. It is then calcined, in a large flat-bottomed, arched furnace, reſembling a baking oven, in which the flame of the wood reverberates upon the ore. The mineral is occaſionally ſtirred or turned during the calcination, with long handled iron hooks or rakes; and the proceſs continued till it ceaſes to emit any fume. An hundred pounds are ſaid to loſe twenty or thirty.

Some

Yellow and red arſenic.

White Arſenic, ſublimed with one tenth its weight of Sulphur, forms a yellow compound, which melts together, if the receiver is heated, into ſemitranſparent

Some relate, that the calcination is repeated ſeveral times, the ore being taken out and ground into powder each time; others, that it is calcined but once, and the calcination continued from four to nine hours, according to the quality of the Cobalt. Some of the aſſayers lay great ſtreſs on the degree of calcination; and report that on this circumſtance, not only the beauty of the colour, but the quantity of coloured glaſs obtainable, in great meaſure depend; and that the degree of calcination which ſome Cobalts require, would be injurious to others. Some, however, ſeem to be of opinion, that Cobalts may be aſſayed with ſufficient accuracy, both in regard to colour and quantity, without any calcination at all, by barely melting the ore with Borax. —— The Cobalt taken out of the calcining furnace is paſſed through very cloſe braſs-wire ſieves; and ſuch part as has concreted into lumps, pounded and ſifted afreſh, till the whole is reduced into fine powder.

During the preparation of the Cobalt, ſome Flints are calcined in another furnace, and thrown red-hot into water; by which they are rendered friable and eaſily pulverable. The pureſt and whiteſt ſtones are made choice of; or ſuch at leaſt as become white by calcination. In want of theſe white ſand is uſed.

Zaffre is compoſed of one part of the calcined Cobalt, and one or two of the calcined Flint, mixed together by ſhaking in a wooden box and ſifting, and then moiſtened with water. Macquer and ſome others report, that a certain quantity of Pot-aſh is added to the above mixture, and the whole imperfectly melted. This account has little probability; as the ſtony powder is very diſtinguiſhable in Zaffre, without any appearance of its having been united with the Cobalt by fuſion; and as the maſſes have the ſhape of the wooden tubs in which they are brought to us, and conſequently cannot owe their hardneſs to fire.

For making the blue Glaſs, called in the maſs *Smalt*, and when powdered *Smalts* or *powder blue*; one part of the calcined ore is mixed with one, two, or more of the Flint, and one or more of Pot-aſh; and the mixture melted in large crucibles in a furnace much reſembling that of the glaſs-houſe. In each furnace are generally ſix crucibles, placed about the middle of its height.

The furnace has two doors, one in the front, the other behind. Through the latter common billets are put in; through the former ſplit wood, dried almoſt to Charcoal in an adjoining oven heated by the furnace. In the front door is an aperture, for introducing ſmall eſſays which is occaſionally cloſed with a piece of loam. In each ſide are three apertures for conveying the matter into the crucibles, and, after fuſion, taking it out with Iron ladles. Above theſe are three others, which are opened occaſionally for introducing the tongs to move or ſettle the crucibles. At the bottom are two more apertures, for taking out the aſhes and ſuch part of the Glaſs as may have run out and fallen down among them; this is melted over again.

After the fire has been continued for ſix hours, the matter is ſtirred every quarter of an hour, with iron rods, to make the mixture the more equal. The fire is kept up in all, for the beſt Smalt twelve hours, for inferior kinds ten or eight. The mark of ſufficient vitrification is, the Glaſs which adheres to the Iron ſtirrer drawing out into a fine thread.

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rent cryſtalline maſſes, called *yellow Arſenic.* If the quantity of Sulphur is doubled, the compound proves more opake, and of a fine red colour, and hence is called

thread. The whole is now taken out with ladles, and poured into a tub of cold water, to render it more eaſily pulverable.

At the bottom of the crucibles is found a metalline Regulus, of a whitiſh colour, inclining to red, and extremely brittle. When the crucibles have become unfit for any further fuſions of the Glaſs, theſe Reguli are melted in them, and are thus reſolved into two diſtinct metallic bodies, one of which falls to the bottom, and another which floats above. The firſt is ſaid to be Biſmuth; the latter is a ſemimetal of a different kind, which yields a blue Glaſs, and accordingly is pulverized and added in freſh mixtures.

The Glaſs appears in the maſs of an opake deep blue, almoſt black; when reduced into moderately fine powder, of a pleaſant light blue; the further it is comminuted the paler. It is firſt beat in a ſtamping-mill, and paſſed through a braſs-wire ſieve, an iron one being apt to ruſt and ſpoil the colour; after which, it is ground with water, on a ſmooth hard ſtone placed at the bottom of a large vat or tub, by two other hard ſtones turning vertically: the water, loaded with the fine powder, is let off by cocks into other veſſels, and ſuffered to ſettle: after the coloured powder has ſubſided, a white one remains ſuſpended in the water, which is now poured off, that the white matter may ſettle by itſelf: this is employed in freſh mixtures in the room of Flint and Potaſh. The coloured powder is waſhed again, dried in a ſtove, paſſed through fine ſieves, and divided into different ſortments, according to the fineneſs of the powder and the beauty of the colour. In the laſt place, it is moiſtened with a little water, and packed up in caſks for exportation.

The richneſs of the Cobalt is judged from the quantity of Flint and Potaſh with which it will form a ſufficiently deep powder blue. The manufactures are provided with aſſayers, for determining the quantities which different parcels of the ore will bear. The produce of Smalt appears to be never leſs than equal, nor more than four times the weight of the crude ore.

Chemical hiſtory of Cobalt.] The colouring matter of Cobalt appears, not, as has been generally ſuppoſed, to be an earth, but a ſemimetal of a peculiar kind, eſſentially diſtinct from all others; revivable, in its proper metallic form, either from the blue Glaſs or the calcined Cobalt, by fuſion with the common inflammable fluxes. To Dr. Brandt, of the Swediſh Academy, we owe the firſt knowledge of this ſubſtance as being a ſemimetal *ſui generis*: it is called *Regulus of Cobalt.*

Cobalt may be looked upon as the ore of this ſemimetal: its other contents are as various and inconſtant as thoſe of any other ores. Almoſt all Cobalts contain a large admixture of Arſenic, ſome of Iron, and others of Biſmuth. The greater number participate alſo of another new ſemimetal firſt diſcovered by Mr. Cronſtedt in the year 1751, and called, from the name of the mineral which yields it moſt plentifully, *Nickel.* The two metallic Reguli, which ſeparate on making the Glaſs, appear to be Biſmuth, and a part of the tinging Regulus of the Cobalt; for it is a property of theſe two ſemimetals not to mingle in fuſion with one another.

The

is called *red Arſenic.* This is of a leſs beautiful red than the combination of Sulphur with Mercury, that is, Cinnabar; and has its colour debaſed, whilſt that of

REGULUS *of* COBALT.

REgulus of Cobalt is a brittle ſemimetal, fuſible in a moderate red heat, nearly the ſame with that in which Silver melts. On continuing the fire, it changes ſlowly into a blackiſh calx; which, urged with a very violent fire, runs at length into a bluiſh black Glaſs. By the addition of different proportions of vitreous matters that have no colour, all the different ſhades may be obtained, from the deepeſt to the lighteſt blue. The glaſſes that are moſt loaded with colour, if held in the flame of a candle, crackle, ſwell, and become white.

It does not amalgamate with Mercury, nor mingle in fuſion with Biſmuth: with this laſt it is rendered miſcible by the mediation of Nickel or of Regulus of Antimony: with all the other metals it mingles readily. It whitens Copper, and renders it brittle, but ſeems remarkably to improve the malleability of Iron: Brandt relates, that the metal obtained in fuſion from a ferrugineous Cobalt-ore, and which was found to be compoſed of Iron with a conſiderable proportion of this Regulus, proved as malleable as the beſt forged Iron: this compound calcined and vitrified, yielded a good Smalt; the black Glaſs, which Iron affords, ſeeming to be of little injury to the blue of the Cobalt.

Regulus of Cobalt, both in its metallic form and in that of a calx, diſſolves readily in Aqua fortis into a red liquor. As few metallic bodies beſides are acted upon by that acid when fully calcined, and as thoſe that are do not influence the colour; we are hence furniſhed with means of diſcovering this Regulus in ores after ſtrong calcination, whatever other metal they may contain.

Solutions of the ſemimetal, or tinctures of the calcined ore, made in the pure nitrous acid, ſuffer no change of colour from heat. If Sea-ſalt or its acid is added, they aſſume a deep emerald green when moderately warmed, and on cooling become red again as at firſt: duly inſpiſſated, they yield roſe-coloured cryſtals, which change their colour in the ſame manner. See p. 170.

Pure Spirit of Salt diſſolves this ſemimetal into a reddiſh yellow liquor, which inſtantly becomes green from a very gentle warmth. On ſaturating

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The blue Glaſs depends on the vitrification of the colouring ſemimetal; and metallic ſubſtances in general cannot be vitrified, or combined with vitreous matters, till they are deprived of their metallic form, and changed into calces. Moſt metals are naturally, in their ores, in the ſtate of calx: the Regulus of Cobalt is often naturally metallic, and ſubſides in its proper form upon bringing the ore into fuſion, without any of the inflammable additions, which moſt other ores require for the revival of their metal. Several ſpecimens of Engliſh Cobalt, moderately roaſted till greateſt part of the Arſenic was judged to be diſſipated, and then melted with different vitreous compoſitions, yielded a large portion of Regulus, the Glaſs acquiring only a browniſh or blackiſh colour, probably from ferrugineous or other heterogeneous admixtures: on ſtrongly calcining the mineral, by long continued fire or by Nitre, the Glaſs turned out blue, and little or no metallic matter ſeparated.

ARSENIC of Cinnabar is improved, by grinding into fine powder. If the quantity of Sulphur is a little increaſed above the proportion which affords the yellow Arſenic, an

orange

ſaturating the ſolution with urinous ſpirits, the Precipitate appears at firſt white, but afterwards becomes blue, and at length yellow.

The vitriolic acid diſſoves this ſemimetal more ſlowly than the two foregoing. The ſolution is of a roſe-colour, and ſuffers no change from heat; but in evaporation, it throws off to the ſides of the glaſs a blue powder, which, on cooling, grows white. Fixt alcalies precipitate from this ſolution a white powder, volatile ſpirits a greyiſh one: on adding more of the ſpirit, the Precipitate is taken up again, and the liquor appears of a beautiful red.

This ſemimetal is precipitated from acids by Zinc, not by Iron.

NICKEL.

NIckel is a white ſemimetal, when compared with Silver inclining a little to reddiſh, of a cloſe texture, and very bright. Its ſpecific gravity is to that of water nearly as 8½ to 1.

It melts in a ſtrong red or light white heat; and, on continuing the fire, riſes up into little eﬄoreſcences, which change at length into a deep green calx. By a longer continuance of an intenſe fire, the calx becomes brown, but does not vitrify, nor is it diſpoſed to vitrification by the addition of Glaſs. Nevertheleſs Borax, fuſed with the ſemimetal itſelf, acquires a conſiderable reddiſh brown tinge: this vitreous matter, further urged, becomes violet, and at laſt colourleſs, like glaſſes tinged with Mangane∫e. Mixtures of Nickel, Regulus of Cobalt and Iron, being ſlightly calcined and fuſed with Borax, the Iron ſeparates firſt in form of a black Glaſs; on repetitions of the proceſs, the Regulus of Cobalt vitrifies, blue; leaving behind the pure Nickel, more difficultly vitreſcible than any other of the imperfect metals.

Nickel makes no conſiderable detonation with Nitre; and is very ſlowly corroded by it into a yellowiſh green fuſible ſcoria. With Sulphur it has a great affinity, abſorbing it from moſt, if not all the other metallic bodies, and detaining it in a very ſtrong fire; even the calces, thoroughly burnt, perfectly unite with it. The ſulphurated Nickel is externally of a bright metallic appearance, internally yellow, very hard, and compact as Steel: it eaſily calcines; and, before a bellows, throws out red ſparkles with conſiderable noiſe.

It refuſes any degree of union with Silver, Quickſilver, and Zinc; but mingles readily with all the other metals, and proves a medium for uniting two repugnant ones, Biſmuth and Regulus of Cobalt. It renders the malleable metals hard and brittle, whitens Gold and Copper, and diſpoſes the latter to tarniſh quickly in the air.

It diſſolves with eaſe in the nitrous and marine acids into a deep green liquor: hence the green tincture which ſome ſorts of Cobalt communicate to theſe menſtrua, and which has generally been attributed to Copper. It is not acted on by the vitriolic acid, whether concentrated or diluted. It is not precipitated from acids by any metal; and but ſlowly by alcaline Salts, into a greeniſh white powder: volatile alcalies, added in larger quantity than is ſufficient to precipitate it, take it up again, the liquor appearing blue.

This

orange coloured Sublimate is obtained. The more the Sulphur is increaſed, to a certain point, the Sublimate proves the redder, and more volatile. When equal parts of each are uſed, the dark red colour is diluted into an aurora, and the mixt concretes into a beautiful tranſparent maſs, called ruby of Sulphur or of Arſenic, or golden Sulphur.

The workmen, in making the red and yellow Arſenics, take, inſtead of white cryſtalline Arſenic, the rough meal as it firſt ſublimes from the ore. Sometimes they mix the meal Arſenic with ſulphureous ores inſtead of Sulphur itſelf, or Sulphur with the arſenical ores; and ſometimes they extract yellow or red Arſenics by one ſingle ſublimation from minerals in which Arſenic and Sulphur are naturally contained. Henckel relates, that the preparation of red and yellow Arſenic, with pure white cryſtalline Arſenic and pure Sulphur, does not ſucceed, or not without great difficulty. But if pure white cryſtalline Arſenic be mixed with one tenth its weight of pure Sulphur, they may be eaſily melted together, in a glaſs body, into a ſemitranſparent, orange-coloured or reddiſh maſs, which ſublimes into a ſemitranſparent, citron-yellow, hard, brittle, ſublimate; a minute portion of more fixed matter remaining at the bottom. The proportions of Arſenic and Sulphur, in theſe kinds of compoſitions, may be judged from their ſpecific gravity; the gravity of Arſenic being to that of Gold as 1 to 5, whilſt the gravity of Sulphur is to Gold only as 1 to 9: hence, the more Sulphur they contain, the lighter; and the more Arſenic, the heavier they will be. The poiſonous quality, which the Arſenic poſſeſſes by itſelf, is, in theſe, conſiderably abated by the Sulphur. They are nevertheleſs far from being innocent: thoſe who are employed in grinding them for the uſe of painters, are apt to become paralytic.

Natural

This ſemimetal, from its great affinity with acids and with Sulphur, and its entire repugnancy to Silver, promiſes to be an uſeful addition for the reduction of Luna cornea and ſulphurated Silver. Mr. Cronſtedt (from whom theſe obſervations are extracted) made ſeveral trials of this kind, and conſtantly found the Silver of perfect purity, lying diſtinct from the Nickel. See the *Svenska vetenskaps academiens handlingur ärs* 1751 & 1754.

Natural mixtures of Arſenic and Sulphur, called *Auripigmenta* or Orpiments, *realgar*, *riſigal*, *ſandaracha*, are not unfrequently met with in the earth, particularly in the eaſtern countries. Mr. Pott has given an excellent diſſertation on Orpiment, from which it may be proper to make a ſhort extract.

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Natural Hiſtory.

"Auripigmentum, ſo called from its being uſed as a gold-coloured Pigment, is the αρσενικον and αρρενικον of the Greeks; the *Harnat*, *Zarnich*, or *Zirnich* of the Arabians; the *Fumus rubeus*, *Gummi Paradiſi*, *&c.* of the alchemiſts. It is commonly ſuppoſed to be the ſame with the factitious yellow Arſenic, and to be poſſeſſed of a poiſonous quality; but it is neither one nor the other. This error ſeems to have proceeded from Agricola's relation, copied by many later writers, that white Arſenic is prepared from Orpiment and common Salt ſublimed together. Hoffman made trial of ſuch a compoſition, but obtained from it no white Arſenic.

Orpiment is a native foſſil, found chiefly in Turky and Natolia. Some is met with alſo in Bohemia, Hungary, and Luſatia near Sorau, but inferior in goodneſs to that of Turky. The beſt ſort is of a lively gold-yellow and green colour, here and there intermixed with pieces of a vermilion red; of a ſhattery foliaceous texture, ſomewhat flexible, ſoft to the touch like Talc, and ſparkling when broke. The inferior kinds are of a dead yellow, inclining more to greeniſh; and want the ſparkling appearance of the foregoing.

Examined by fire.

It burns in the fire, but not very eaſily, with a deep blue, or a dark bluiſh white flame and a ſulphureous ſmell; and at the ſame time melts and becomes red. If the fire is continued, it ariſes in white or rather yellowiſh white fumes, which condenſe partly into reddiſh and partly into white flowers; an earthy, ſandy, or ſtony matter remaining behind. Hoffman obſerves, that the fume of Orpiment ſtains a knife of a yellowiſh white and reddiſh colour; and ſays, that the red Arſenic of the ancients was no other than

Orpiment melted into a cinnabarine red maſs. Cramer relates, that as ſoon as it burns it melts, and being then poured out upon a clean Marble or Iron plate, forms, on cooling, a deep red ſemitranſparent, compact, brittle ſubſtance; leaving a porous ſparkling matter, reſembling an imperfect ſcoria, leſs fuſible than the Orpiment at firſt, and which, in a ſtrong fire, falls into a grey earth.

Depilatory

Orpiment conſiſts of Sulphur and Arſenic. Some affirm that it has a corroſive quality, ſo as to make the hair fall off, and hence ſuppoſe it to conſiſt of acrimonious Salts. But Orpiment of itſelf has no ſuch power: it is a mixture of it with Quick-lime which has that effect, and Quick-lime will produce the ſame effect without it.

Sympathetic Ink.

A Lixivium made boiling by Orpiment in Lime-water, gives colour to inviſible writings with the ſympathetic Ink. The ſympathetic Ink is a ſolution of Litharge in Vinegar, or Sugar of Lead. This ſolution, written with on paper, leaves no ſtain, any more than pure water: but if a piece of bibulous paper, dipt in the ſolution of Orpiment and thoroughly dried, be laid upon the writing, the characters will preſently become black and legible. The ſame bibulous paper impregnated with the Orpiment, will anſwer repeatedly for a length of time: it will likewiſe produce its effect, though more ſlowly, without the immediate contact of the writing, and even with a thick book interpoſed betwixt them.

Method of diſcovering Lead in Liquors.

A like black colour reſults upon mixing the ſolutions of Orpiment and of Lead; and hence we are furniſhed with means for diſcovering the dangerous fraud of impregnating wines with Litharge: if the Wine, on being mixed with the ſolution of Auripigment, acquires a browniſh red or blackiſh colour, we may be ſure it has ſuffered that abuſe. The production of the colour in theſe experiments proceeds from the ſulphureous part of the Orpiment tinging or tarniſhing the particles of Lead.

Compoſed of Sulphur and Arſenic.

That Orpiment contains Sulphur appears from hence; that one part of Orpiment with half a part of

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Nitre and Salt of Tartar, mixed together, and expoſed to the fire, flaſh and explode with great vehemence; a phænomenon never obſerved from Nitre and Salt of Tartar without Sulphur. Agricola ſurely never tried the proceſs which he directs in his notes on Poppius, of ſubliming this fulminating compoſition in a glaſs body for the ſpace of ten hours: if ſuch a proceſs was attempted, the veſſels would ſoon be burſt in pieces, to the hazard of the operator's life. A mixture of Orpiment and Nitre, injected into a red-hot crucible, deflagrates with a bright flame, in the ſame manner as a mixture of Sulphur and Nitre: ſome white arſenical flowers ariſe, and the remainder is a fixed Arſenic. It were needleſs to bring more evidences of Orpiment containing Sulphur, when the fine Cinnabar parable from Orpiment and Mercury-ſublimate is of itſelf an inconteſtible proof.

That this mineral contains Arſenic, appears from the arſenical flowers which it yields in the fire, and the fixt Arſenic which remains upon deflagrating it with Nitre: this reſiduum whitens Copper in the ſame manner as common fixt Arſenic. Arſenic, melted with alcaline Salt and Sope or other fat matters, yields a ſparkling Regulus; and Orpiment, treated in the ſame manner, affords a Regulus agreeing in all reſpects with the other. The Alcali abſorbing the Sulphur of the Orpiment, forms with it a hepar Sulphuris; which diſſolves in water, and, on the addition of Vinegar, depoſites a ſulphureous Precipitate, in the ſame manner as the antimonial ſcoria. The following experiment puts this affair beyond diſpute. If equal parts of Orpiment and Sope be well mixed together, the mixture put into a glaſs retort, and the fire gradually raiſed; at firſt, a whitiſh, unctuous, ſulphureous liquor ariſes; next a portion of the Sulphur of the Orpiment ſublimes into the neck of the retort, partly tinged blackiſh by the Oil of the Sope, and partly appearing yellow and reddiſh; at laſt, in a red heat, a ſparkling Regulus, the ſame with Regulus of Arſenic, ſublimes: a ſmall

Regulus of Arſenic.

portion of the Sulphur of the Orpiment remains behind, detained by the Alcali of the Sope. The ſulphureous Sublimate participates of the arſenical matter of the Orpiment, and hence diſcovers a poiſonous quality, though in a far leſs degree than the Regulus, or the white flowers of Orpiment.

Products from Orpiment, with Sublimate.

Half a pound of Orpiment, and a pound of Mercury-ſublimate, were well mixed together, put into a wide-necked glaſs retort, and ſuffered to ſtand for a day and night in a cellar; a large receiver being then adapted and cloſely luted, a gentle fire applied and increaſed by degrees; there ariſes a conſiderable quantity of a ſmoking ſpirit, clear and tranſparent as water, called butter of Arſenic or of Orpiment: this is followed by an oily liquor, which, like vegetable oils, ſwims upon the ſpirit, and if an hundred times forced under it, ſtill riſes to the ſurface again: on further increaſing the fire, a conſiderable proportion of Cinnabar ſublimes; and there remains, in the bottom of the retort, a little yellow, light, crumbly matter, which is the earth of the Orpiment. There aroſe alſo a little arſenicated Sulphur, not ſaturated with the Mercury, of a red colour, reſembling a ruby. Some direct, for this proceſs, equal parts of the Orpiment and Mercury-ſublimate; but unleſs the Sublimate is taken in a larger quantity, its acid will be inſufficient to diſſolve and elevate the Arſenic, and its Mercury inſufficient to form a true Cinnabar with the Sulphur. The ſame thing happens in this operation, as in the making of butter of Antimony: the marine acid of the Sublimate quits the Mercury, to unite with the arſenical Regulus with which it has a greater affinity; whilſt the Mercury of the Sublimate unites with the Sulphur of the Orpiment. The greater fluidity of the butter of Orpiment than of the butter of Antimony depends on the different qualities of their metallic part; the Regulus of Orpiment being more ſubtile, fuſible, volatile, of greater activity upon metallic bodies, than the Regulus of Antimony. The butter of Orpiment, dropt into water,

depoſites

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depoſites a white powder in the ſame manner as butter of Antimony does: this powder, edulcorated, and ſet to ſublime in a Silver box cloſely luted, corrodes the Silver, ſo as to render it in part ſpongy like a Pumice. Cobalt, Biſmuth-ore, and the red Silver-ore, which are all arſenical, have the ſame effect upon Silver. If the butter or Spirit of Orpiment be mixed with Spirit of Nitre, and ſet to diſtil, the phænomena are the ſame as when butter of Antimony is treated with that acid: a powder, which is no other than fixed Arſenic, remains; and an Aqua regia ariſes, impregnated with a part of the Arſenic, ſo as to render Gold white; whence ſome have been induced to believe, that the tinging matter of Gold was extracted by this menſtruum.

With regard to the oil, it has been ſuppoſed by ſome not to proceed from the Orpiment, and to be no other than a ſolution of a part of the Mercury-ſublimate: but the ſame kind of liquor is obtainable, without the addition of any Mercury-ſublimate, from Orpiment and common Salt, with a ſuitable quantity of Oil of Vitriol to extricate the acid of the Salt: Arſenic treated in the ſame manner yields no ſuch oil. This oil, dropt into water, renders the liquor turbid. On the addition of Oil of Vitriol, it coagulates, and a kind of ſlimy matter ſubſides: if water be now poured in, a white oil appears at the bottom, which, on ſtanding, diſſolves into a clear liquor: if the liquor be then evaporated, it becomes brown, is difficultly brought to dryneſs, and depoſites a ſaline ſediment. The oil, mixed with Aqua regia, ſettles alſo to the bottom. With ſtrong Spirit of Nitre, it does the ſame; but on digeſtion it is diſſolved: the liquor becomes brown in evaporation, and is difficultly exſiccated, but yields no ſediment; diluted afreſh with water, it appears yellow. Alcalies, both fixed and volatile, added to the oil, occaſion a precipitation.

With different acids.

Spirit of Salt poured upon Orpiment in powder, makes a ſlight efferveſcence, but no ſolution or change enſues;

Orpiment.

enſues; the ſulphureous part of the mineral defending the metallic from the action of the acid. Orpiment being mixed with Aqua fortis into the conſiſtence of a paſte, an effervefcence begins after ſtanding about half an hour, and nitrous vapours plentifully ariſe, till all the acid is diſſipated: the reſiduum being moiſtened afreſh with Aqua fortis, the ſame phænomena ſucceed, and the matter afterwards grows hard: even if ten parts of the acid are employed to one of Orpiment, nitrous vapours conſtantly and copiouſly exhale. If a little of the mixture be ſet to ſhoot, ſome fine cryſtals like hairs are obtained: if the maſs be evaporated to dryneſs, it will liquefy on ſtanding in a cellar, and being then mixed with a large portion of Aqua fortis, occaſions at firſt a ſlight effervefcence, without any further change. It is pretty remarkable, that a large quantity of Aqua fortis added at firſt to the Orpiment, has no effect. Oil of Vitriol, by coction and abſtraction from Orpiment, partly diſſolves it: the late profeſſor Schulze, at Hall, obſerves, that equal parts of Orpiment and Oil of Vitriol, ſet to diſtil in a ſtrong fire, yielded at firſt a phlegm, and afterwards a ſubſtance like an oil, ſmelling like Opium; a ſmall portion of an aſhy matter being left in the retort. When Arſenic is treated with Oil of Vitriol, there ariſes a little Sublimate reſembling plumous Alum, which deſerves further examination: ſee Hoffman's *Obſervationes phyſ. chem.* Aqua regia does not act upon Orpiment any more than ſpirit of Salt; except that a little of the arſenical matter may be extracted by the nitrous ſpirit in the compound acid. The Regulus, and white flowers, diſſolve more eaſily, both in the nitrous and marine acid, and in compoſitions of them. Spirit of Sal ammoniac, all urinous ſpirits, diſtilled and expreſſed oils, extract from Orpiment a yellow tincture; theſe menſtrua diſſolving its ſulphureous part.

Hoffman diſtilled Orpiment with common Salt, and obtained firſt an acid phlegm, afterwards yellow

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flowers, and at length, in a ſtrong fire, a tranſparent red maſs, which adhered to the ſides of the glaſs. Glauber diſſolved it in the liquamen of fixed Nitre, mixed the ſolution with the ſecret Sal ammoniac, and on diſtilling the mixture, gained an acidulous and urinous phlegm, afterwards a ponderous, yellow, unctuous liquid reſembling vegetable oils, and at laſt a blood-red tranſparent Sublimate like an oriental ruby. Kunckel relates, that Orpiment diſtilled with Nitre in a tubulated retort, yields a nitrous and ſulphureous ſpirit, participating of Arſenic, with a large quantity of flowers; and that white Arſenic, with equal or thrice its weight of Nitre, injected into a red-hot tubulated retort, yields a like ſpirit, but ſtronger, and of a bluiſh colour, which diſſolves metals, and whitens Copper. Meuder informs us, that Orpiment being ſublimed with an equal quantity of Iron filings, and ten parts of the Sublimate ground on a ſtone with twelve parts of cryſtals of Silver; the mixture laid on a piece of paper, inſtantly took fire."

Pyrophorus.

Not poiſonous.

This mineral, though it manifeſtly contains Arſenic, is not found to be poiſonous; the Arſenic being corrected and mitigated by the large proportion of Sulphur, in the ſame manner as the virulence of Regulus of Antimony is obtunded by that concrete: pure white Arſenic, combined with equal its weight of Sulphur, loſes its poiſonous quality, and becomes innocent.

Depilatory.

Four ounces of Quick-lime, an ounce and a half of Orpiment, an ounce of Florence orris root, half an ounce of Nitre, and half an ounce of Sulphur, boiled, with a ſtrong ley drawn from the aſhes of bean ſtalks, till the matter becomes conſiſtent, then mixed with half an ounce of Oil of Spike, make the compoſition for taking off the hair; the part being afterwards anointed with Oil of Roſes. Strong Sope-leys are an equally effectual and more ſimple depilatory. It is ſaid, that the juice of henbane prevents the growth of hair.

The

ORPIMENT.

The principal uſe of Orpiment is, as a colouring drug, among the painters, bookbinders, *&c.* Of itſelf it makes a gold-coloured Pigment; with Indigo or other blues, a green: it is commonly tempered with yolk of eggs and a little ſaffron, or with fiſh galls. At Rouen, it is uſed for ſtaining wood of the colour of box-wood. It is mixed alſo with wax, employed for heightening the colour of Gold, for hardening Lead in order to the making of ſhot, and for colouring glaſs, as may be ſeen in Kunckel's *Ars vitriaria.* Equal parts of Arſenic, Mercury, Tin, and Sal ammoniac, are ſaid to afford in ſublimation a purple-coloured Pigment.

Uſe as a Pigment, *&c.*

SECT. III.

MINERAL SALTS.

SALTS.

Simple Salts, acid and alcaline.

THERE are two general claſſes of ſimple Salts, Acids and Alcalies. *Acids* are diſtinguiſhed by their ſour taſte; effervеſcing with and diſſolving certain earths, as the aſhes of vegetables; and changing the colour of the blue flowers of plants or their infuſions to a red. *Alcalies* are diſtinguiſhed by a pungent taſte, extremely different from ſourneſs; by their deſtroying the acidity of every kind of ſour liquor; diſſolving Sulphur by boiling; and changing the colour of blue and red flowers to a green. Liquors impregnated with one kind of Salt raiſe an efferveſcence on being mixed with thoſe of the other, greater or leſs in proportion to their ſtrength. Subſtances diſſolved in one are precipitated by the other; and in this caſe there often happens no efferveſcence upon mixture. In whatever manner they are mixed, the Acid and Alcali unite into one uniform *neutral* compound, giving no marks either of one or the other. When thus combined, in ſuch proportions as that neither may prevail, they are ſaid to be *ſaturated* with one another, or mixed to the point of *ſaturation*. This term is applied alſo to the ſolution of different ſubſtances in theſe or other liquors: thus, when a liquor has diſſolved as much of any body as it is capable of holding ſuſpended, it is ſaid to be ſaturated with that body.

Neutral Salts.

Different kinds of acids.

In the mineral kingdom there are three kinds of acids, naturally blended with alcalies, earths, metals, or other bodies, into neutral and other ſaline concretes. The ſubjects from which theſe acids have been moſt commonly extracted are, Vitriol, Nitre, and Sea-ſalt; and hence they are diſtinguiſhed by the names of *vitriolic*, *nitrous*, and *marine*. All the three are volatile in the fire, totally exhaling, when pure, in a heat below ignition; though, when combined with fixed bodies, they reſiſt a much ſtronger heat, and from ſome are ſcarce to be diſunited by any degree of fire. The nitrous and marine acids are always obtained in the form of a thin liquor, the acid Salt being blended with a large proportion of water, without which it would be diffuſed into an incoercible vapour. The vitriolic ſtands in need of ſo much leſs water for its condenſation, as to aſſume commonly a thick, and in ſome circumſtances a ſolid conſiſtence.

and of alcalies.

Alcaline Salts are of two kinds; one *fixed* in a ſtrong fire; the other *volatile* in a gentle warmth. The production of theſe from vegetables and animals will be treated of hereafter. We ſhall here only obſerve, that, volatile alcalies are very rarely met with in the mineral kingdom; but that a peculiar fixed alcali differing from thoſe of vegetables is often found in combination with the marine and vitriolic acids.

CLASS I.

Vitriolic Acid and its combinations.

VITR. ACID.

In what bodies contained.

THE vitriolic acid is diffuſed throughout the earth, the waters of the ocean, and the atmoſpherical regions; and is ſuppoſed by ſome to be the baſis of all the other acids both mineral and vegetable: whence it is named by the chemiſts, the univerſal, primogenial, vague acid. In the mineral kingdom, it is found in great abundance; not in a ſeparate or pure ſtate, but combined with various other bodies; with the inflammable principle, into Sulphur; with certain metals, into vitriols; with mineral alcalies, into the Salt called Sal mirabile; with one kind of earth into Alum; with another into ſelenitic concretes. Argillaceous earths, the coloured earths and ſtones, metallic ores, the ſolid bitumens, VITR. ACID. bitumens, the mineral oils and waters, are all impregnated, more or leſs, with this acid or its combinations. Fixt alcaline Salts imbibe it from the air; and thus are changed in part into a neutral Salt, ſimilar on all trials to one prepared by combining the alcali directly with the common vitriolic acid.

When this acid is united with alcaline Salts either fixed or volatile, it cannot be expelled from them by any degree of fire. Nor is it ſeparable any otherwiſe, than by transferring it into ſome third body, with which it has a greater appetite of union. From ſundry earths, we can force it out by fire alone; and from the metallic bodies, with which it is naturally united, into Vitriol, ſtill more eaſily, though ſcarce totally; a part of the acid being retained both by the metals and earths, after the action of a very vehement fire. It is from Vitriol, that this acid has hitherto been chiefly extracted for common uſes; whence its name *vitriolic*. When very largely diluted with water, ſo as to be but juſt ſenſibly acid, it is called *phlegm*; when leſs diluted, or more acid, *ſpirit*; and when ſo little diluted, or ſo far freed from water, as to aſſume a thick conſiſtence, *oil*, of Vitriol.

Gravity. Oil of Vitriol is the moſt ponderous of all known fluids, except Quickſilver and ſome metallic ſolutions. Fahrenheit determines its ſpecific gravity to be to that of water as 18,775 to 10,000. Fixity. It is conſiderably more fixed than any of the other acids; emitting no fumes or ſmell in the greateſt heat of the atmoſphere, or even in that of boiling water; and requiring, to make it boil or diſtil, a much ſtronger fire than any other ſaline liquor, a fire almoſt ſufficient to make the containing veſſel red-hot.

Imbibes moiſture from the air. Expoſed to the air, it imbibes humidity, ſo as to acquire a notable augmentation of its weight, greater or leſs, ſooner or later, according as the ſurface of the liquor is larger or ſmaller, and the atmoſphere itſelf more or leſs moiſt. Dr. Gould, profeſſor at Oxford, relates, that three drachms of Oil of Vitriol acquired, in fifty-ſeven days, an increaſe of ſix drachms and a half *(m)*. Hoffman obſerves, that an ounce and two ſcruples, in an open glaſs diſh, gained, in fourteen days, ſeven drachms and a ſcruple. I expoſed an ounce to the air, in a low glaſs body, from September 1736 to September 1737: at the end of the twelvemonth, it weighed ſeven ounces and two drachms, and thus had attracted from the air above ſix times its own weight of moiſture.

Raiſes heat with water and ice.

If Oil of Vitriol and water are mingled haſtily together, the mixture becomes inſtantly ſo hot as to render the veſſel inſupportable to the hand *(n)*. Great caution is requiſite in mixing any kind of liquor with this acid; leſt the glaſs ſhould crack from the ſudden heat which it produces, or a part of the matter be thrown about with violence during the ebullition, to the manifeſt danger of the operator. We ſhould always add the acid, by little and little at a time, to the other liquor, and never attempt to pour the latter into the former. It is obſervable, that a piece of ice, laid on the ſurface of Oil of Vitriol, ſoon melts, and, when melted, flows diſtinct above the acid. If the ice and the acid are ſhaken together, they incorporate and grow hot, as when the acid is mixed with water.

Strongly retains water.

The vitriolic acid, diluted with water, ſtrongly retains a conſiderable quantity of the aqueous fluid; pre-

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(m) *Dr. Gould's experiments of Oil of Vitriol imbibing moiſture from the air.*] The doctor further informs us, that the increaſe in the firſt day was upwards of one drachm; in the following days, leſs and leſs; till on the fifty-ſixth, it ſcarce amounted to half a grain. That this experiment was made in a glaſs of three inches diameter. That the ſame quantity of the acid, expoſed to the air at the ſame time, in a glaſs of only one inch, gained but one ninth ſo much as the other, which is exactly the proportion of their ſurfaces. That the liquor, when ſaturated with humidity, retained, or loſt part of its acquired weight, according as the air was moiſt or dry; and that this difference was ſo ſenſible, as to afford an accurate hygrometer *.

(n) *Heat from the mixture of Oil of Vitriol and water.*] About equal parts, by weight, of the two liquors, produce the greateſt heat. Hoffman ſays in one place equal parts, in another one part of the acid to two of water †. Probably in the firſt he means by weight, in the latter by meaſure.

* *Phil. Tranſ.* No. 156. † *Hoffm. Obſ. phyſico-chem.* p. 150, 167.

preventing its exhalation in a heat wherein pure water would ſoon be diſſipated; and ariſing in part along with it by a fire inſufficient to elevate the undiluted acid. The further it is diluted, the more eaſily it evaporates.

Reduced to a ſolid ſtate

Oil of Vitriol is capable of being ſo far freed from water, as to aſſume a ſolid, butyraceous or icy conſiſtence. I have examined this point with particular care, as it has been greatly controverted, and ſeems to have been miſrepreſented by all the chemical writers; ſome affirming, that the vitriolic acid, when highly concentrated, freezes in winter, and in winter only; and others, as Stahl, that it never congeals at all, unleſs extremely diluted with water. I found that common Oil of Vitriol continued fluid in the winter as well as in ſummer; that a more concentrated oil, which continued fluid during the ſummer, congealed in winter; and that when the acid is ſtill further freed from phlegm, it becomes conſiſtent in the hotteſt weather. Put ſome good Oil of Vitriol into a glaſs retort, diſtil off about three fourths of it, and let the remaining fourth be cloſely ſecured from the air; the acid thus concentrated will, at any ſeaſon of the year, look like butter or ice by the time it is grown cool. A certain chemiſt thought to obtain this coagulated oil, without the trouble of diſtillation in a retort, by evaporating the more phlegmatic part of common Oil of Vitriol in an open glaſs. He complained to me, that though he had ſeen a good quantity of vapours exhale, the remaining liquor, when grown thoroughly cold, not only refuſed to coagulate, but weighed as much as at firſt. The cauſe was obvious: the Oil of Vitriol, ever greedy of humidity, had imbibed as much from the air as it had loſt in the fire. The ſame individual liquor being put into a retort, and about one half diſtilled off; the reſiduum, excluded from the air, aſſumed now a conſiſtent form.

Oil of Vitriol ſaturates a larger quantity of fixed alcaline Salt than any other acid. Five parts of this acid are ſufficient for eight or more of the alcali, whilſt the ſtrongeſt of the others is incapable of ſatiating its own weight (*o*). The acid part of the liquor being here abſorbed by the alcali, its aqueous part is ſet at liberty, ſo as to ariſe with eaſe in evaporation or diſtillation. The diſtilled fluid, though it has no manifeſt taſte, is ſaid to differ in ſome reſpects from pure water; to be more ſubtile and penetrating, and to exhale much ſooner in an equal degree of heat: it is called by Niednerus, *ſpiritus mundi (p)*. The remaining Salt, perfectly exſiccated, diſcovers, by its increaſe of weight above that of the dry alcali employed, the quantity of ſaline matter it has received from the acid liquor, and conſequently the proportion of pure acid which that liquor contains. By this method, an ounce of good Oil of Vitriol is found to conſiſt of about five drachms of acid, and three of water.

VITR. ACID. Quantity of Alcali it ſaturates, and of pure acid it contains.

The vitriolic acid loſes its attraction for water, by the union of any of thoſe ſubſtances which are capable of being combined with it; even of thoſe, which, ſeparately, are as greedy of humidity as itſelf, as fixed alcaline Salts; and of thoſe by which all other acids acquire the property of attracting moiſture, as calcareous earths. It never promotes the fuſibility or volatility of bodies, as the others in many inſtances do; but on the contrary retards fuſion, and increaſes fixity. Thus vegetable fixt alcaline Salts, a powerful flux for ſundry refractory matters, and which flow eaſily when ſaturated with other acids; earths and metals, which with other acids yield compounds eaſy of

General relations to other bodies.

(*o*) *Alcali ſaturated by Oil of Vitriol.*] It is obſervable, that this acid does not ſaturate ſo much, by one half or more, of volatile alcaline Salts, as it does of the fixed. The nitrous acid ſeems to ſatiate a larger proportion of volatile alcalies than the vitriolic.

(*p*) *Water diſtilled from Oil of Vitriol and Salt of Tartar.*] This liquor is ſaid alſo to diſſolve leaf-gold: and when drank, even in a doſe of a ſpoonful, to excite a diaphoreſis. I have tried it with Gold, but could not obſerve that it had any action on that metal.

of fuſion; when combined with the vitriolic, cannot be made to melt at all.

Expels all other acids from alcalies and earths.

The vitriolic is the moſt powerful of all the acids; though there are many ſubſtances, which it does not act upon ſo violently, or diſſolve ſo readily, as ſome of the others do (*q*). If any other acid be combined with an alcaline Salt, the addition of the vitriolic will take the alcali from it. The acid before combined, though it could not be expelled by fire alone, will now readily exhale, and leave the vitriolic in poſſeſſion of the alcali. On this principle depends the diſtillation of the acid ſpirits of Nitre and Sea-ſalt. Hence alſo we are furniſhed with a method of diſcovering which of the mineral acids any compound Salt contains. Oil of Vitriol has no action on thoſe, which hold no other acid than the vitriolic itſelf, but effervesces with the others, and immediately extricates a part of the acid in vapours. The particular acid may be diſtinguiſhed by the colour and ſmell of the fumes.

How it influences fermentation and putrefaction.

The vitriolic acid retards fermentation and putrefaction; but has this effect in a leſs degree than the other acids, whether employed in its pure ſtate, or combined with other bodies. How little it is diſpoſed to prevent putrefaction when united with certain metals, appears from the mouldineſs to which common ink is ſubject.

Applied to the human body.

Hoffman obſerves, that the concentrated acid, or Oil of Vitriol, applied ſlightly and ſuperficially to the ſkin of a living animal, raiſes a violent burning heat and

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(*q*) *Vitriolic acid moſt powerful.*] The *powerfulneſs*, *activity*, and *ſtrength* of acids, are to be carefully diſtinguiſhed; as being three properties independent of one another, though commonly confounded together. The vitriolic is more *powerful* than any of the others, as it expels them all from alcaline Salts both fixed and volatile, and from the ſoluble earths; and takes poſſeſſion itſelf of the Alcali or earth. It is leſs *active*, or acts more languidly and difficultly, upon moſt bodies, than either the nitrous or marine. In its concentrated ſtate, it is the *ſtrongeſt* of acids, as containing the largeſt quantity of pure acid in proportion to the phlegm or water. However *weakened* by dilution, it ſtill continues the moſt *powerful*. By thus *weakening* it its *activity* is oftentimes *increaſed*. Vegetable acids may be made *ſtronger* than the marine, but ſtill continue *leſs powerful*, as being expelled by it from alcalies and earths.

and pain; but that a larger quantity, preſſed cloſe on the part, ſo as to prevent the ingreſs of the aereal moiſture, occaſions little pain or eroſion. If the oil is diluted with a little water, it proves corroſive in either caſe.

Medical uſes.

The vitriolic acid, largely diluted with water, is employed medicinally for preventing a putrefactive diſpoſition, correcting bilious acrimony, abating heat, quenching thirſt; in debilities of the ſtomach, and in the heartburn. To perſons of weak or unſound lungs, to women who give ſuck, to hydropic and emaciated perſons, it is injurious. Some recommend it as a collyrium for ſore eyes; but as it coagulates the animal juices, and corrodes and indurates the ſolids, it is ſurely very unfit for being applied to that tender organ.

ARTICLE I.

Combination of the vitriolic acid with inflammable matter.

Becomes coloured from the contact of inflammable ſubſtances.

OIL of Vitriol, however limpid and clear, becomes yellowiſh, brown, reddiſh, black, from the bare contact of any inflammable matter, as a ſmall bit of cork, paper, wax, bladder, or other like ſubſtances, which give no conſiderable tincture to any liquor beſides. The whiteſt camphor and ſugar, the moſt limpid eſſential oils and diſtilled inflammable ſpirits, have the ſame effect. It is obſervable that ſome ſubſtances, as Camphor and Oil of Turpentine, give a colour to the acid only in its concentrated ſtate; and that the colour produced diſappears again upon diluting the liquor. Camphor put into Oil of Vitriol, is diſſolved by it, loſes its own ſtrong penetrating ſmell, and renders the liquor black like pitch. On adding a quantity of water to the pitchy mixt, the Camphor inſtantly recovers its odour, and the acid its colourleſs pellucidity.

Phænomena with vinous ſpirits.

Oil of Vitriol, dropt into eight times its weight or more of highly rectified Spirit of Wine, by a little

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VITR. ACID. at a time, to prevent any immoderate ebullition or diſcharge of vapours, forms with it on digeſtion for ſome days, a reddiſh liquor; which being committed to diſtillation, great part of the acid ariſes along with the vinous ſpirit by a very gentle heat; an acid bituminous, ſulphureous matter remaining. The diſtilled liquor, impregnated with a volatilized Oil of Vitriol, has a fragrant ſmell, and diſcovers no acidity to the taſte; and hence is called *dulcified Spirit of Vitriol.* In length of time, however, its fragrance diminiſhes, and the latent acid begins to reſume its acidity.

With oils. Oil of Vitriol mixed with diſtilled oils, occaſions great heat, effervеſcence, and ſulphureous fumes; and unites with the oil into a dark coloured maſs, like Pitch or Bitumen, from which a portion of Sulphur is producible. On expreſſed oils, it acts much leſs violently than on the diſtilled. An account of its particular effects on different oils may be ſeen in Hoffman's *Obſervationes Chemicæ.*

Volatilized In the extraction of the vitriolic acid from Vitriol or other fixed bodies by vehemence of heat; if the diſtilling veſſel had any fiſſure, or contracted any in the fire, the acid receives a remarkable alteration. It now proves extremely volatile; emitting pungent and almoſt ſuffocating vapours in the air, and totally ariſing in diſtillation by a heat ſcarce too great for the hand to bear. It is ſo much leſs corroſive than the acid in its fixed ſtate, as to be ſafely taſted; when it diſcovers only a ſlight biting bitteriſhneſs and roughneſs, with ſcarce any ſenſible acidity. It neutrallizes fixed alcaline Salts; but inſtead of expelling, it is itſelf expelled from them by both the other mineral acids (r). This volatile ſpirit, kept for ſome time in a veſſel not cloſely ſtopt, loſes it's ſuffocating odour, reſumes its fixity, acidity, and all its former qualities.

(r) *Volatile Spirit of Vitriol.*] This ſpirit, though it ſcarce diſcovers any acidity to the taſte, raiſes a conſiderable effervеſcence with alcaline Salts both fixed and volatile, and ſaturates a large proportion of them. It inſtantly loſes its pungent odour on the admixture of the Alcali. The mixture ſhoots into ſmall cryſtals, which, on the affuſion of any other acid, yield up the vitriolic again, as volatile and ſuffocating

VITR. ACID.

Production of Sulphur.

The vitriolic acid, freed from phlegm, and combined by fire with a due proportion of any inflammable matter, is changed into a ſolid, inſipid concrete *Sulphur*. Thus when the concentrated acid is mixed with oils, and the phlegmatic part drawn off, a true Sulphur may be ſublimed from the reſiduum. If the acid be ſaturated with an alcaline Salt, as the alcali of Sea-ſalt with which it forms a fuſible compound, the aqueous part of the mixture evaporated, and the remaining Salt (called *Sal mirabile*) melted with ſome powdered charcoal; the reſult will be, not a combination of the Alcali and vitriolic acid as at firſt, but of Alcali and Sulphur; from which the Sulphur is eaſily ſeparable by ſolution in water, and precipitation with any acid.

SULPHUR *or* BRIMSTONE.

SULPHUR.

THE name Sulphur has been applied by ſome to the inflammable principle of bodies; by others, to all inflammable mixts, or ſubſtances participating of this principle; and the alchemiſts ſpeak alſo of a Sulphur that does not burn. Vegetable oils and reſins, animal fats, mineral bitumens, are by ſome called Sulphurs; and by ſome, Sulphur itſelf is referred to the bitumens. This confuſion has given riſe to numerous errors and abſurdities. How widely different is true Sulphur, in all its properties, from bitumens, or oils, or any other kind of inflammable body! If every thing that burns was to be called Sulphur, we might with the ſame propriety call every thing that is liquid by the name of water, or of ſpirit of wine, or vinegar, or oil, or any other particular liquor.

Experiment

ſuffocating as it was received. This ſpirit deſtroys or whitens the blue and red colours of the flowers of plants; whilſt in its fixed ſtate, like other acids, it changes the blue to red, and heightens thoſe which were naturally of that colour.

SUL-PHUR. Experiment has fully evinced, that Sulphur is no other than the concentrated vitriolic acid combined with a ſmall proportion of the phlogiſtic or inflammable principle; and to this combination alone, which is always one and the ſame excepting for adventitious admixtures, the more judicious chemiſts have wholly confined the name.

General properties. Sulphur is a ſolid brittle concrete, of a yellow colour inclining a little to greeniſh, in ſome degree gloſſy. Held in the warm hand, it crackles and burſts: and leaves on the hand a particular kind of ſmell. It is nearly twice as heavy as an equal bulk of water.

Fuſion. It melts in a ſmall degree of heat into a red pellucid fluid, and, on cooling, concretes again into its original appearance. Some have endeavoured to purify Sulphur from the droſſy matters which are often mixed with it, by melting and pouring it into Spirit of Wine. Others have melted it with wax, and poured the fluid mixture into water, when the Sulphur ſubſides, and the wax ariſes to the ſurface, carrying up with it a part of the impurities. With regard to Spirit of Wine, it can have no effect in ſeparating foreign matters from the Sulphur, though it ſeems in ſome meaſure to heighten the yellow colour. Wax on the other hand renders it greener, and if the fuſion is ſeveral times repeated, changes it quite blackiſh.

Sublimation. Sulphur kept in fuſion, gradually exhales. If the air is excluded, it ſublimes into the upper part of the veſſel, without undergoing any other alteration, than being reduced into the form of powder or flowers. This property affords a method of purifying it effectually from earthy, ſtony, or other fixed matters; and at the ſame time of reducing it into a finer powder than can eaſily be obtained by trituration. Where only a ſmall quantity of flowers of Sulphur is wanted, the ſublimation may be performed in a jar, with aludels cloſely luted upon it, and a blind-head at top. In England, they are prepared by particular perſons in the way of trade. The ſubliming veſſel is an Iron pot, ſo large as to hold two or three hundred weight or more of Sulphur, about a fourth of its capacity remaining empty. The recipient is an arched room built above the pot, and communicating with it at one ſide by an aperture of ſix or eight or more inches in diameter. The room is lined with glazed tiles; and furniſhed with a door, by which a man may creep in, when the operation is finiſhed, to ſweep out the flowers. In the middle of the door is a ſmall hole, which is opened occaſionally during the ſublimation, for examining whether the flowers continue or have ceaſed to ariſe.

Acid ſpirit

In open veſſels, Sulphur readily takes fire from the contact of ignited bodies, and if kept in fuſion, burns entirely away, with a blue flame, and a diffuſive ſuffocating fume (*s*). This fume is no other than the vitriolic acid volatilized by the flame. A conſiderable quantity of it may be detained, and condenſed into a liquid form, by placing over the burning Sulphur capacious glaſs veſſels, replete with aqueous vapours. The larger the receivers, and the leſs communication the flame has with the external air, the more of the fumes will be preſerved.

Methods of collecting the acid.

The moſt common apparatus for this purpoſe conſiſts of a little earthen diſh, for burning the Sulphur in; a glaſs bell, ſuſpended over the flame; and a broad glaſs or earthen veſſel, which ſupports the diſh with the Sulphur, and receives the acid liquor as it drops from the ſides of the bell. Many variations have been made in this apparatus, with a view to detain the fumes more effectually. Inſtead of the bell (from which the acid has received the name of *Spiritus ſulphuris per campanam*) ſome have employed a glaſs differing from that ſhape in having a rim turned in at the bottom, and a tube at the top, to which a receiver

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(*s*) *Inflammability of Sulphur.*] Stahl obſerves, that an ounce of Sulphur, burnt with a wick, may be made to yield a conſtant flame, for ſix hours; and that, when the wick was very ſmall, only fifteen or ſixteen grains were conſumed in an hour. See *Stahlii exp.* CCC *numero chymicæ & phyſicæ.*

SUL-PHUR.

ceiver is fitted as an enlargement of the capacity of the veſſel; others a retort, with its bottom cut out, and a glaſs body or tubulated receiver applied to its neck; others a receiver, with a hole in its bottom for admitting the flame; others a glaſs body with ſome water in its bottom, holes in the ſides, a crucible with burning Sulphur placed in the water, and another body inverted on the mouth. Some have ſuſpended the burning Sulphur in a wooden caſk half full of water, and afterwards rectified the liquor. The grand difficulty is, that Sulphur will not burn without a draught of air, and the acid fumes are ſo volatile that far the greateſt part of them is carried off by the air. Some direct a little Nitre to be mixed with the Sulphur, to promote its burning; but though Nitre is undoubtedly of advantage in that reſpect, it is injurious in another; rendering the product impure, by giving out its own acid along with that of the Sulphur. Many other contrivances have been made, but none with any commendable ſucceſs; the ſame acid being obtainable at a much cheaper rate from Vitriol, than by any of the methods of procedure to which Sulphur has hitherto been ſubmitted (t). The beſt way hitherto diſcovered of collecting the acid ſpirit of Sulphur in a volatile ſtate, is that given by Stahl. The Sulphur is made to burn ſlowly by means of a wick, a number of aludels ſet over it, and a cloth moiſtened with ſtrong alcaline ley placed in each aludel. As ſoon as any of the clothes become dry, a moiſt one is put in its room. The alcaline Salt which the clothes were impregnated with, imbibes the acid fumes, and is thus converted into a neutral Salt, which is eaſily rubbed out. It is the volatile vitriolic acid that this Salt contains; and hence, upon adding to it common Oil of Vitriol, in a tubulated retort, the volatile ſpirit diſtils, leaving the Alcali combined with the more powerful fixed acid ſuperadded. The volatile however, as well as the fixed acid, is ſtill more commodiouſly and advantageouſly obtainable from Vitriol itſelf.

(t) *Method of collecting the acid of Sulphur.*] This proceſs has of late been ſo far improved, by ſome particular perſons, as to furniſh, at a very low price, almoſt all the acid now ſold under the name of Oil of Vitriol. The improvement conſiſts, in employing very large glaſs veſſels of the capacity of a hogſhead or more, in which is placed a little water, whoſe ſteam collects and condenſes the fumes; but principally in mixing with the Sulphur a ſmall portion of Nitre, about ſix pounds to an hundred weight, which enables it to burn much more ſpeedily than Sulphur by itſelf, and without communication with the external air. By this means nearly all the fumes are preſerved. It does not appear, that the ſpirit thus collected contains any of the nitrous acid; for the acid of Nitre is deſtroyed by deflagration. See *Nitre.*

Its acid the ſame with that of Vitriol.

It was formerly ſuppoſed, that the acid ſpirits of Vitriol and Sulphur were really different from one another, and hence they were received in the ſhops as two diſtinct acids. Their identity is evident from hence; that the ſpirit obtained from common Sulphur, united with metals, forms a true Vitriol; and the ſpirit extracted from common Vitriol forms, with inflammable ſubſtances, a perfect Sulphur, not diſtinguiſhable on any trial from pure mineral Brimſtone. We ſhall ſee hereafter, that common Vitriol is a production from ſulphureous minerals; and that the acid of the Vitriol is the very individual acid, which before entered the compoſition of the Sulphur.

Menſtrua of Sulphur.

Sulphur does not diſſolve in water, in Spirit of Wine, or in acid liquors. The vitriolic acid, nevertheleſs, extracts a part of the acid of the Sulphur, ſo as to gain a conſiderable increaſe of its own acidity (*u*). Fixed alcaline Salts, injected upon half their weight or leſs of melted Sulpur, readily unite with it into a red or liver-coloured maſs, called *hepar ſulphuris*, which deliquiates in the air, diſſolves in water, and gives a golden tincture to Spirit of Wine. The watery ſolution, kept for ſome time, generally depoſites a black powder. Sulphur is diſſolved alſo by boiling in fixt alcaline Lixivia, or in Lime-water. The

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(*u*) *Effect of menſtrua*, &c.] Sulphur repeatedly melted and quenched in water, aſſumes a degree of tranſparency, but of ſhort duration. By treating it in the ſame manner with Spirit of Wine, its yellow colour, as formerly obſerved, is ſomewhat improved. The marine acid, long boiled on Sulphur, or repeatedly abſtracted from Sulphur, is ſaid to render it conſiderably tranſparent; the vitriolic to make it leſs inflammable, and more fixed in the fire; the nitrous, to occaſion no change.

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The addition of any acid to theſe ſolutions, renders them milky, and precipitates the Sulphur in form of a white powder called *lac ſulphuris*. During the precipitation, an extremely fetid vapour ariſes, which blackens metalline utenſils, particularly ſilver ones, at a conſiderable diſtance *(x)*.

Reſolution of Sulphur by fixed alcalies.

If the mixture of Sulphur and fixed alcaline Salt be reduced to powder, kept for ſome time in a gentle heat, and frequently ſtirred; the Sulphur will be deſtroyed, or reſolved into its conſtituent parts. The inflammable principle is gradually diſſipated, and only the acid of the Sulphur remains combined with the Alcali. Inſtead of a red, fetid, alcaline, ſulphureous compound, we find now a white, inodorous, neutral Salt, the ſame as if common Oil of Vitriol had been mixed with the Alcali. From this experiment we are enabled to determine the proportions of acid and phlogiſton of which Sulphur conſiſts; the increaſe of weight which the alcaline Salt acquires being pure concentrated acid. It appears upon careful trial, that in ſixteen ounces of Sulphur, there are upwards of fifteen ounces and ſix drachms of pure vitriolic acid void of phlegm; the inflammable matter, by which ſo large a quantity of that moſt corroſive acid is in all its properties ſo ſurpriſingly changed, amounting only to about a drachm.

Proportions of acid and phlogiſton

Solution in volatile ſpirits.

Some report that Sulphur will diſſolve in volatile alcaline ſpirits, without any intermedium. Boerhaave directs, for this purpoſe, any ſtrong alcaline ſpirit to be diſtilled from flowers of Sulphur, and cohobated or drawn over a ſecond time from the reſiduum; or the mixture to be long kept in a cloſe veſſel, and frequently ſhaken. I tried ſtrong ſpirits of Sal ammoniac, both ſimple and dulcified, prepared both with alcaline Salt and with Quick-lime, and a ſpirit ſaturated with Oil of Aniſeeds. But none of the five made any ſolution, or extracted any tincture from the Sulphur, either by digeſtion or diſtillation.

(x) *Precipitation from alcalies and Lime.*] The Precipitate, though of a white colour, does not ſeem to differ in quality from what the Sulphur was at firſt, provided it has been carefully waſhed from the adhering ſaline matter. On ſublimation, or ſimple fuſion, it reſumes its orignal yellow colour. It is obſervable, that fixed alcaline Salts precipitate Sulphur from the ſolution made by Quick-lime; and that the fetid ſmell, ſo ſtrong in all the precipitations of Sulphur by acids, is not here perceivable.

There are means, however, of procuring a perfect ſolution of Sulphur in volatile ſpirits; namely, by mixing the Sulphur, not with the ſpirit already prepared, but with crude Sal ammoniac; and adding Quick-lime to extricate the volatile Alcali, which thus will elevate with it in diſtillation a conſiderable portion of the Sulphur. Beguinus takes four parts of Sulphur, two of Quick-lime, and one of Sal ammoniac. Hoffmann's proportions, three parts of Lime, two of Sal ammoniac, and one of Sulphur, ſucceeded better with me. The mixture is to be put into a retort, and diſtilled by a gradual fire, the juncture of the retort with the receiver being cloſely luted. The diſtilled liquor called ſulphureous Spirit of Sal ammoniac, ſmoking Spirit of Sulphur, or volatile Tincture of Sulphur, is extremely volatile and penetrating, emits highly fetid vapours, which blacken Silver, and give colour to inviſible writings made with ſaturnine ſolutions, like the liquor of Orpiment, page 237. It is employed medicinally in ſome compoſitions; internally as a ſudorific, and externally as an antipodagric.

Solution in oils.

Various balſams.

Sulphur diſſolves in oils, by the aſſiſtance of boiling heat, into a thick, yellowiſh, or reddiſh fluid, called Balſam or oily liver of Sulphur. This proceſs ſhould be performed without doors, in large veſſels; the matter conſtantly watched and ſtirred, and, if it begins to riſe up, removed immediately from the fire: otherwiſe the combuſtible compound will ſuddenly run over into the furnace, and may be productive of terrible conſequences. One of my people very narrowly eſcaped from ſuch an accident with his life, and will carry the effects of it to his grave.

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Expreſſed oils diſſolve Sulphur far more readily and plentifully than the diſtilled. The balſams of Sulphur with diſtilled oils, directed in books of pharmacy, are very injudicious preparations; as the oil will ſcarcely gain any tincture from the Sulphur, without a boiling heat; and ſuch a heat will deſtroy the flavour and peculiar qualities of the oil. If theſe kinds of preparations are wanted, they may be much more commodiouſly and advantageouſly obtained by adding a due proportion of any eſſential oil to the ſolution made with expreſſed ones. Expreſſed oils will eaſily take up half their weight of Sulphur, and form with it, when grown cold, a thick conſiſtent maſs. If this be liquefied by a gentle heat, and any eſſential oil added, they will readily incorporate together. The eſſential oil of Aniſeed differs remarkably from all the other diſtilled oils, in its power of diſſolving Sulphur; taking up rather more even than the expreſſed. This oil, digeſted with the *hepar ſulphuris*, or compoſitions of Sulphur and fixed alcaline Salts, readily takes up a large quantity of Sulphur from the Alcali. Other eſſential oils abſorb very little; and expreſſed ones ſcarce any at all. It is obſervable that the balſam of Sulphur with oil of Turpentine, if ſaturated with the Sulphur whilſt hot, concretes on cooling into a curious vegetation reſembling a tree.

Effects of Sulphur on metals.

Sulphur unites in the fire with moſt metallic bodies, promotes the fuſion of the refractory ones Iron and Copper, renders Lead on the other hand almoſt unfuſible, and debaſes the quality of them all.

Artificial ores.

It changes ſeveral into the appearance of their own ores; Silver into a ſoft leaden coloured ſubſtance, reſembling the malleable Silver ore; Iron and Copper into yellowiſh concretes, like the natural Pyritæ; the antimonial Regulus into Antimony; Quickſilver and Arſenic into red compounds, the ſame withthe native Cinnabar and red Arſenic; Lead, into a dark-coloured maſs, like its common ore; Tin, into a ſubſtance like Antimony, a form in which that metal is never found in the earth. Pure Sulphur does not act upon Gold, but ſulphurated Alcali or *hepar ſulphuris* unites with Gold in fuſion as well as with other metals, and renders it diſſoluble in water ſo as to paſs through the pores of a filter (*y*).

Gunpowder.

The principal uſe of Sulphur is in fire-works, and for making gunpowder. The diſcovery of gunpowder is attributed by ſome to an Engliſh monk, Roger Bacon; by others to a monk of Freyberg, Berthold Schwartz, about the year 1380. Whoever was the inventor, the diſcovery was doubtleſs accidental; for who could have expected, from any artificial compoſition, the aſtoniſhing effects of gunpowder. The ingredients are Nitre, Charcoal, and Sulphur; the proportions of which are different in different works, and generally kept a ſecret. The Sulphur is commonly in ſmalleſt quantity,

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(*y*) *Effects of Sulphur on metals.*] It unites with all the metals and ſemimetals, except Gold, Platina, and Zinc; but ſcarcely acts upon metallic calces, excepting thoſe of Lead and Nickel. It promotes the fuſion of Iron, Copper, Silver, and Regulus of Antimony; and impedes that of Lead and Tin, particularly that of the former.

Though Sulphur is, by itſelf, very volatile in the fire, it adheres ſo ſtrongly to metallic ſubſtances, as not to be eaſily expelled. It is not diſſipable from any metal in cloſe veſſels. In open ones it may be entirely diſſipated from Silver, Tin, Biſmuth, and Regulus of Antimony; the firſt of which it leaves uninjured, or in its perfect metallic form; the others in that of a calx. To Copper of all metals it adheres the moſt ſtrongly; and hence the difficulty of extracting pure Copper from its ſulphureous ores. The acids which diſſolve metals by themſelves, and oils and alcaline liquors, which diſſolve Sulphur, do not, unleſs in a few inſtances, effectually extract either when combined with the other; the one defending the other from the action of its appropriated menſtrua.

Different metallic bodies have different degrees of affinity or attraction to Sulphur, Arſenic the leaſt. When Sulphur is combined with Arſenic, it will part with the Arſenic on adding Quickſilver; with which laſt it remains united at the bottom of the veſſel, whilſt the Arſenic, more volatile than that compound, ſublimes pure. If Regulus of Antimony is joined to the ſulphurated Mercury, the Quickſilver is ſet at liberty, and diſtils by itſelf, leaving the Sulphur behind in poſſeſſion of the Regulus. Silver abſorbs it from that ſemimetal, forming with the Sulphur a kind of ſcoria, which flows diſtinct upon the ſurface: In like manner Biſmuth takes it up from the Silver; Tin from Biſmuth; Lead from Tin; Copper from Lead; and Iron from all the foregoing: hence the uſe of Iron filings in the aſſaying and ſmelting of ſulphureous ores.

Fixed alcaline Salts abſorb Sulphur in fuſion from all the metals; but as ſoon as they have taken up the Sulphur, the compound which they form with it begins to re-diſſolve the metal. This compound acts more powerfully on metals than Sulphur by itſelf, entirely deſtroys their metallic aſpect, and renders moſt of them ſoluble in water. Zinc is the only metallic ſubſtance which reſiſts this compoſition.

SULPHUR

quantity, and the Nitre in the largeſt. Some take but one part of Sulphur to ſeven of Nitre: others three or four of Nitre to one of Sulphur and one of Charcoal: others two parts of coals to one of Sulphur. There are differences alſo in the choice of the Charcoal, and the Sulphur, and the purification of the Nitre. Among us, the powder made at Liſſa in Poland has been always accounted the beſt. Lemery ſays, the Sulphur ſhould be previouſly freed from a part of its fixed alcaline Salt. Sulphur has nothing of any ſuch Salt to loſe, but it would be proper, if it would anſwer in point of expence, to ſeparate the earthy impurities by ſublimation. It is not the Sulphur in the compound that firſt takes fire, as the above-mentioned author imagines, but the Charcoal. I mixed Sulphur and Nitre in ſixteen different proportions, but none of the mixtures would take fire from a ſpark, without the addition of ſome animal or vegetable inflammable matter. —Sulphur is employed likewiſe in ſome woollen manufactures, in bleaching, for making Cinnabar, by the wine coopers, for ſundry œconomical and other like purpoſes. —It is uſed medicinally againſt cutaneous eruptions, and diſorders of the lungs. From the virtues attributed to it in this laſt intention, it has received the name of *anima pulmonum*.

Medical uſe.

Natural hiſtory.

Sulphur is ſometimes found native in the earth, in pure, bright yellow, ſemi-tranſparent maſſes; but more commonly in opake ones, of a greeniſh, greyiſh, or other colours, intermixed with various earthy or ſtony matters. Theſe impure ſorts are thoſe commonly underſtood by the name of *Sulphur vivum.* The native Sulphurs are met with chiefly about Volcanos in Italy, in ſome of the German, Hungarian, and Swediſh mines. A pale yellow tranſparent Sulphur is brought from Guadaloupe in America, and called by the French *Soufre de Guadaloupe, de guido*, or *de quittau.* Monardus mentions a *Sulphur vivum præſtantiſſimum* as he calls it, tranſparent as Glaſs, and in colour like Gold.

Red Sulphur.

There are likewiſe reddiſh, and red Sulphurs; of which I have ſeen ſome of a ſemitranſparent cinnabarine red. Theſe are never to be employed for medicinal uſe, as they are rarely free from an admixture of Arſenic, and indeed are rather to be looked upon as a native red Arſenic or Realgar, than as Sulphurs. The redder the colour, the more Arſenic they generally hold (z). The greateſt quantities of theſe red arſenical Sulphurs are found in the Turkiſh dominions; and ſome in the territories of Saltzburg.

Authors mention another ſort of native Sulphur, which ſeparates from the hot mineral waters, particularly thoſe of Aix-la-chapelle. Whether this yellow ſediment be a true Sulphur or not, I cannot determine, as I have not had an opportunity of examining it.

Sulphur in ores.

Sulphur is an ingredient in moſt kinds of ores, and frequently is the only one by which metallic bodies are debaſed in the earth into that form. Tin, Biſmuth, and Cobalt, are the only ones which have no Sulphur in their ores. Arſenic and Gold are frequently accompanied with it; Silver, a good deal more frequently; and Lead ſtill more ſo. Of Copper it is a more conſtant attendant than any of the foregoing. Mercury and Regulus of Antimony are never found without it. The common ores of Iron rarely hold any Sulphur. The mineral, however, which contains the largeſt quantity of Sulphur, or from which the Sulphur is extracted to the greateſt advantage, is a ferrugineous ore, called, from its colour,

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(z) *Arſenicated Sulphur.*] Here it may be obſerved, that moſt ſorts of native Sulphur participate of Arſenic; though the quantity of Arſenic is commonly too ſmall to be diſcoverable by any reddiſh or orange caſt, till a part of the Sulphur has been exhaled by fire or detained by additions. This obſervation is to be particularly attended to in peruſing the writings of the ancient chemiſts, who frequently direct Sulphur to be ſublimed repeatedly from iron filings or other matters, till it becomes *red and tranſparent like a ruby*; an effect in vain expected from the pure Sulphur we are now ſupplied with, but which readily ſucceeds with the arſenicated mineral ſorts which were then made uſe of.

SULPHUR. colour, and from its ſtriking fire with Steel, *yellow Pyrites.*

Method of extracting. The yellow *Pyritæ* are found moſt plentifully in ſome parts of Sweden, and in Saxony, where the principal Sulphur works are eſtabliſhed. The Sulphur is extracted in ſome places by diſtillation in large iron retorts. In others, by eliquation in earthen veſſels; the Sulphur, as it melts out from the ore, being conveyed along inclined pipes into veſſels of cold water. At Goſlar, in the lower Saxony, great quantities of Sulphur are collected in the calcination of certain ores in the open air. The ore being ſtratified with wood, and the wood ſet on fire, the Sulphur melts out in different parts of the pile, and is received in veſſels placed underneath, or in cavities made for that purpoſe in the matter itſelf when ſoftened by the heat. The rough Sulphur obtained by theſe proceſſes is purified by fuſion; which is ſometimes twice or thrice repeated. The lighter feculencies, which ariſe to the ſurface, are ſkimmed off; and the fluid Sulphur poured from the groſſer ſediment that falls to the bottom. Moſt of the Sulphur prepared in Germany appears of a fine yellow colour, or inclines but a little to greeniſh yellow. The Swediſh, particularly that which comes from the iſland Melo, has more of the green, and is not near ſo fine. The impure Sulphur, or dregs remaining after the purification, are called *Sulphur caballinum*, as being only fit for horſes. But even for ſuch purpoſes, it is ſurely more adviſable to uſe pure Sulphur, than an unequall and unknown mineral medley, which may often do more harm than good.

Whether contained in the air. Hoffman and others have preſumed, that Sulphur exiſts in the air, and that from this proceed thunder, lightning, and other fiery meteors; the vitriolic acid and inflammable principle, the very ingredients from which art produces Sulphur, being unqueſtionably diffuſed through the atmoſphere. Plauſible as this theory may appear, it is liable to conſiderable objections. Art cannot produce Sulphur without a degree of fire, which we cannot ſuppoſe to have any place in the atmoſphere: no Sulphur can be generated but with the concentrated acid, and how infinitely, on the other hand, is the aërial acid divided and diluted! beſides, the effects of Sulphur and of lightning are in nowiſe ſimilar.

Sulphur.

Article II.

Combination of the vitriolic acid with metallic bodies.

Vitriols.

General relation to metals.

THE vitriolic acid, in its diluted ſtate, and aſſiſted by a moderate warmth, very eaſily diſſolves Iron and Zinc; the firſt into a green, the other into a colourleſs liquor. Copper is more difficultly acted on: this metal requires the ſtrong, undiluted, acid or oil, and a heat ſufficient to make it boil: the more phlegmatic part of the liquor exhaling during the coction, ſo much of the acid remains united with the Copper, as to render it ſoluble in water: this ſolution is of a fine blue colour. Silver, Quickſilver, Tin, Lead, and Regulus of Antimony, are likewiſe corroded by boiling in the concentrated acid, but are not ſo effectually diſſolved by it as the three foregoing metals. Gold is not acted upon at all by the pure vitriolic acid however concentrated or heated; though when the acid is converted into Sulphur, and then combined with fixed alcaline Salts into a Hepar. Gold is diſſolved with this compound equally with the other metals.

Comparative affinity to metals.

The vitriolic acid has a greater affinity with moſt metals than any of the other acids have. Thus, if added to a ſolution of Silver, for inſtance, made in the nitrous acid, it will attract the metal from that acid, and carry it to the bottom. This rule does not obtain univerſally, but the exceptions are very few: the principal exception is the ſtrong affinity of the marine acid with the metal above-mentioned; this acid

VITRIOLS.

acid carrying down Silver from the vitriolic, as readily as the vitriolic does from the nitrous *(a)*.

Reſolution of Sulphur by metallic ſubſtances.

The vitriolic acid diſcovers in general a ſtronger attraction to the inflammable principle than to any other known ſpecies of matter; and when combined with it, forms Sulphur. There are circumſtances, however, in which it forſakes that principle, to unite with ſome metallic bodies, particularly Iron and Copper. If either of theſe metals be combined with Sulphur, and the compound gently roaſted or calcined, only the inflammable part of the Sulphur will be diſſipated, its acid being retained by the metal, which is thus corroded into a ſaline concrete, the ſame as if the pure acid had been applied. The ſame change is producible, without the application of any external heat, from a bare mixture of Iron filings and Sulphur moiſtened with water: the matter grows hot of itſelf, the Sulphur is reſolved into its conſtituent parts, its inflammable principle exhales, and its acid is detained by the Iron. From moſt of the other metals, Sulphur is expelled by fire in its whole ſubſtance.

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(a) *Affinities of the vitriolic acid with metallic ſubſtances.*] The vitriolic acid, like the others, has the greateſt affinity, among metallic bodies, with Zinc, which diſlodges from it all the others: the next, in degree of attraction, are Nickel, Regulus of Cobalt, and Iron; next to theſe Copper; and after this Quickſilver. Like other acids alſo, on adding a volatile Alcali to the metallic ſolutions, it depoſites the metal, and unites with the Alcali; and this it will again forſake for a fixed Alcali.

In ſome circumſtances, however, this acid diſcovers a greater attraction to metals than to fixt alcalies themſelves; and in this reſpect it differs from all the other acids. If fixed alcaline Salt, ſaturated with the vitriolic acid, that is, vitriolated Tartar) be added to a ſolution of Mercury or Silver; the acid inſtantly forſakes the Alcali, unites with the metal, diſlodges it from the former ſolvent, and carries it to the bottom.

Hence we are furniſhed with a ſolution of the problem which Stahl ſome time ago propoſed to the chemiſts, "to ſeparate the vitriolic acid "from fixed alcaline Salts, inſtantly, and in the palm of the hand." Mr. Geoffroy has given a Memoir on this problem; in which he endeavours to reſolve it by changing the acid into Sulphur; namely, by melting the vitriolated Alcali with inflammable matters by a ſtrong fire, till the acid is combined with the phlogiſton into Sulphur; (ſee page 252.) then diſſolving the compound in water, and precipitating the Sulphur with acids: he thinks it ſufficient that this laſt part of the proceſs be performed in the hand, though the ſeparation of the acid was effected in the fire.

Production of Vitriol.

A like reſolution happens often ſpontaneouſly in the mineral kingdom. There are ſundry minerals which, examined in their natural ſtate, appear to conſiſt of Iron and Copper, blended with Sulphur, and earthy or ſtony matters. After they have been expoſed for a time to the action of the air, we find nothing of the Sulphur left but the acid, by which the metal is now corroded into a ſaline ſubſtance ſeparable from the indiſſoluble matter by means of water.

Combinations of metals with the vitriolic acid are called *vitriols* of thoſe metals. It is with manifeſt impropriety that Boerhaave and others have extended this name to metallic Salts made with other acids: for, as one particular acid is univerſally diſtinguiſhed by no other name than that of the acid of Vitriol, it muſt ſurely be productive of great confuſion, to call thoſe ſubſtances Vitriols, whoſe acid is of a different kind.

VITRIOL.

Different ſorts of Vitriols.

THERE are Vitriols of three metallic bodies, produced ſpontaneouſly, or with little aſſiſtance from art; thoſe of Iron, of Copper, and of Zinc. The pure vitriol of Iron is of a graſs-green colour verging to blackiſh; that of Copper, of a beautiful ſapphire blue; and that of Zinc white. The Vitriol of one metal has frequently an admixture of that of another; and hence ariſes a fourth arangement, of greeniſh blue and bluiſh-green, according as Iron or Copper prevail in the compound (*b*).

Method of preparing them.

Vitriols are prepared in Sweden, in ſeveral parts of Germany, &c. from the yellow ſulphureous Pyritæ, whoſe metallic part is chiefly Iron; and from ſome other minerals of the ſame kind, impregnated with Copper. The firſt are of a pale yellow colour, and commonly

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(*b*) *Vitriols.*] Theſe Salts are remarkably lighter than might be expected from the large quantity of metallic matter they contain: even when freed by fire from their watery phlegm, they are leſs ponderous than the Salts compoſed of the ſame acid and fixed alcalies, in the proportion of about 2 to $2\frac{3}{10}$.

commonly approach to a cubical figure: the latter are of a deeper greeniſh yellow or Gold colour, and in figure more irregular. Both ſorts are compact and hard, and diſcover in their natural ſtate no marks of Vitriol, but yield Sulphur in abundance. Expoſed to the atmoſphere, either intire or reduced into powder, they ſuffer no perceptible change; but if gently roaſted or calcined, and then laid for a time in the air, they acquire a ſtrong vitriolic taſte, and readily give out to water the Vitriol now produced in them. Thoſe in which the quantity of Sulphur greatly prevails above that of the metallic matter, are worked for Sulphur firſt: after ſo much of the Sulphur has been extracted, as can be commodiouſly ſeparated by the common proceſſes of ſublimation or eliquation, enough is ſtill retained by the metal to convert greateſt part of it into Vitriol.

English Copperas ſtones.

There are other kinds of Pyritæ, very different in quality from the foregoing. Thoſe from which Vitriol of Iron is prepared in large quantity at Deptford near London, and which are brought thither by water, chiefly from the Iſle of Wight, under the name of Copperas ſtones, contain very little Sulphur, though on expoſure to the air they become plentifully impregnated with vitriolic acid; and hold a ſtill ſmaller portion of Iron, inſomuch that it is neceſſary to add freſh Iron to ſaturate the acid. Theſe ſtones are conſiderably hard and compact, commonly of a roundiſh figure, of a ſparkling whitiſh grey colour, ſometimes as large as the fiſt, and ſometimes much ſmaller. They have no manner of taſte, and give out nothing to water by long boiling. Diſtilled in a retort, they yield a little ſulphureous Sublimate, and a browniſh or milky liquor of a ſtrong ſulphureous ſmell: on the reſiduum I made forty different experiments with reductive fluxes, but obtained no appearance of any metallic Regulus. The crude ſtones, expoſed entire to the air, loſe their brightneſs, and change to a dull grey colour; the ſuperficial parts ſcale off, and become powdery; and by degrees the whole ſtone is converted into powder without the leaſt aſſiſtance from art. What was before Sulphur, is now vitriolic acid: the powder has a ſtrong, acid, ſtyptic, vitriolic taſte; and yields, with the addition of Iron or Copper, a green or a blue Vitriol. The ſtones are found to differ in regard to the length of time neceſſary for producing theſe changes: for ſome, a few weeks are ſufficient; others require a twelvemonth; and others, as Boyle obſerves, a year and a half.

Vitrioleſcent wood.

Theſe kinds of ſtones are not peculiar to England. There are Pyritæ in ſeveral other countries, at Saalfeld, in Heſſia, in Bohemia, about Leige, *&c.* which yield Vitriol by like treatment; and require no calcination or other artificial operations, to render them vitriolic. The bituminous wood, found plentifully in the pits where Amber is dug, becomes alſo vitriolic by lying in the air; and a very little air is ſufficient for that effect. I kept ſome hard compact pieces of this wood, in a covered box, in a temperate place, for ſome years: they retained their figure, and ſtill exhibited marks of the woody fibres, but fell in powder on being touched, and appeared throughout vitriolic: ſome other pieces, kept for the ſame length of time in a cloſe ſtopt glaſs, retained a degree of firmneſs. Pyritæ are likewiſe converted into a vitriolic ſtate in covered veſſels, though more ſlowly than in the open air.

Preparation of Copperas at Deptford.

At the Vitriol works at Deptford, the ſtones are ſpread, to the depth of about half a foot, upon an area of ſeveral hundred roods, whoſe bottom is compoſed of clay, mixed perhaps with other ſubſtances, made ſloping, and beat ſolid and ſmooth, ſo as that water may run off. From the upper ſide of the grounds to the lower are dug ſmall channels, at diſtances of about ten paces; by which the vitriolic matter, waſhed out from the mineral by rains, is carried down into wooden troughs placed tranſverſely at the lower ſide. Every two of theſe troughs empty themſelves into a wooden ciſtern ſunk in the ground betwixt them. From theſe the liquor is laded up with wooden jets. If ſufficiently ſtrong, it is conveyed along a trough into the boiling-houſe: if too dilute, from immoderate rains or other cauſes, it is returned, by another canal properly diſpoſed for that purpoſe, upon the ſtones in the upper part of the vitriol ground. In great droughts, the deficiency of rain is ſupplied by artificial watering. — The vitriolic liquor is boiled down in large, oblong, ſhallow, leaden pans, with the addition of ſuch old Iron as is procurable at a cheap rate. When evaporated to a proper pitch for ſhooting, it is conveyed by troughs into long pits made in the earth, narrow at bottom, and wider at top. In theſe great part of the Vitriol cryſtallizes; after which the uncryſtallized liquor is returned to the boilers with freſh vitriolic ley; and the proceſs repeated till ſcarce any thing more will ſhoot. This liquor is purchaſed by ſome particular perſons, under the name of mother-ley. When the workmen have large quantities, they return it upon ſuch Pyritæ as have not been completely changed into a vitrioleſcent ſtate. The cryſtallized Vitriol is carried into the drying-houſe; and, after ſufficient exſiccation, packed up in caſks for ſale. The work is carried on without intermiſſion; the Vitriol grounds being divided into a number of compartments, that one parcel of the mineral may be ready to yield its acid, by the time that another is exhauſted.

Cryſtallization.

Deptford is the only place where Vitriol is cryſtallized in pits made in the earth. The cryſtallization is commonly performed in large wooden tubs fitted with perforated covers; a long ſtick being thruſt through every hole of the cover, to the bottom of the veſſel, for the Vitriol to ſhoot upon. The ſticks are frequently joined in pairs, by croſs pieces at the lower end, like the Greek Π. The cryſtals are knocked off, dried a little, and put up in caſks.

Vitriolic waters.

There are ſundry waters naturally impregnated with Vitriol; the greater number with that of Iron; ſome with that of Copper; to which, in ſome waters, the Vitriol of Zinc is ſuperadded. All the Chalybeate ſprings, as thoſe of Pyrmont, receive their

Virtues from a Vitriol of Iron, produced by a ſpontaneous reſolution of Pyritæ. The vitriolic acid has a principal ſhare in the impregnation of all the mineral waters. Even thoſe which contain an alcaline Salt, as the Carlſbade waters, ſeem to owe their Alcali to this very acid. This alcaline Salt differs in ſeveral reſpects from vegetable alcalies, and appears to be the ſame with the baſis of Sea-ſalt. There is abundant reaſon to believe, that it has been actually taken from Sea-ſalt by the vitriolic acid; and that this acid afterwards forſook, and left it in the water, to unite with ſomething elſe, perhaps with calcareous earths; for the vitriolic acid has a ſtrong attraction to theſe earths, and, when combined with them, forms an inſipid ſelenitic concrete, which we find really to exiſt in waters (c).

In many places we meet with cryſtals of Vitriol ſpontaneouſly formed in the earth, as at Rammelſberg near Goſlar

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(c) *Impregnation of mineral waters.*] From the foregoing ſhort ſketch of the impregnation of mineral waters, our author appears to have had a more thorough knowledge of this ſubject than any who has written ſince. Mineral ſpirits, unſupported by experiment, have been called in aid to account for the phænomena; whilſt the natural affinities of the vitriolic acid, and its obvious tranſpoſitions from one body into another, have been overlooked. The following experiments tend to confirm the authors ſuggeſtions, and will probably give ſome further light into this affair.

1. If common Salt and Vitriol of Iron be diſſolved ſeparately in water, and then mixed together, the ferrugineous part of the Vitriol will ſeparate and fall to the bottom, its acid uniting with the alcaline baſis of the Sea-ſalt, and forming with that a new compound, the *cathartic Salt* or *Sal mirabile* of Glauber.

2. If, inſtead of Sea-ſalt or its ſolution, we take the earthy ſubſtance called *Magneſia alba*, or a ſolution of it in the vegetable, nitrous, or marine acids, a like reſolution happens, the acid of the Vitriol depoſiting its metallic baſis, and uniting with the earth. The new ſaline compound, produced in this caſe, is the *bitter cathartic Salt*, the ſame with that obtained from the purging mineral waters.

3. On mixing a ſolution of *Glauber's Salt* with calcareous earths or ſolutions of them, Lime-water for inſtance; the vitriolic acid of the Glauber's Salt forſakes its alcaline baſis, and unites with the calcareous earth: with this laſt it forms a ſelenitic concrete, very ſparingly diſſoluble in water, and which, on ſtanding, in greateſt part ſubſides, leaving in the little liquor other than the diſengaged alcaline Salt. It is needleſs to mention, that if the quantity of Glauber's Salt is large, in proportion to that of the calcareous earth, only a part of it will thus be reſolved.

4. On ſubſtituting the *bitter cathartic Salt* to Glauber's Salt, the event is the ſame; calcareous earths abſorbing a part of the acid of that Salt alſo, more or leſs in proportion to their own quantity, and forming

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Native Vitriols.

Goſlar in Hungary, *&c.* Theſe alſo appear to receive their origin from Pyritæ. At Rammelſberg there is abundance of ſulphureous Pyritæ, both cupreous and ferrugineous. Twenty-five or twenty-ſix hundred weight of Sulphur are prepared there every week; and about eight hundred weight of Vitriol. As at this place there is plenty of the ingredients for the production of Vitriol, ſo neither are the means wanting for its being produced in the mine itſelf. There is heat ſufficient from the wood fires made for burſting the hard maſſes of ore, for gunpowder is never employed for that purpoſe here. A whole ſtack of wood is ſet on fire at a time, by which the mine is made ſo hot, that the men are obliged to work naked. Water, as in all mines, is but too plentiful;

forming with it a ſelenites. Only here, as the baſis of the bitter purging Salt is an earth not diſſoluble in water, this earth ſeparates and ſubſides, as ſoon as it is deprived of its acid. As the earthy matter, which remains upon evaporating the purging mineral waters, conſiſts partly of this earth, and partly of Selenites, we may preſume, that a part of the ſalt of the water was thus deſtroyed in the evaporation; that a part of its acid was transferred from one kind of earth into another; from an earth with which it forms a bitter cathartic Salt, into one with which it compoſes a ſubſtance inſipid to the taſte, and of no purgative virtue. Hence we learn, why the waters themſelves purge more, than the Salt obtainable from an equal quantity of them.

5. If equal quantities of green Vitriol and the mineral alcaline Salt or baſis of Sea-ſalt, be dropt into a ſtrong bottle filled with ſpring-water, and the mouth inſtantly cloſed ſo as to leave no vacuity in the veſſel; the two Salts will be ſlowly diſſolved, and ſubſiſt quietly together ſo long as the veſſel is kept cloſely ſtopped; there being no room for the extrication of the air, which all acids expel from alcalies in uniting with them, and without the expulſion of which they cannot unite with them. As ſoon as the bottle is opened, the Salts begin to act upon one another, and the liquor exhibits the ſame remarkable phænomena, as the natural Chalybeate waters when brought up into the open air. It ſparkles or emits bubbles of air, taſtes briſk or ſpirituous as it is called, gives marks both of acidity and alcaleſcence, ſtrikes with galls, not the black which Vitriol does by itſelf, but a fine purple. On ſtanding for a little time, it loſes theſe qualities; the Vitriol is deſtroyed; its Iron falls to the bottom in form of Orchre, its acid being abſorbed by the Alcali. The remaining liquor, evaporated, leaves only a little cathartic Salt, and a part of the Alcali unneutralized; together with a portion of marine Salt and different earths, which the ſpring-water contained before.

This experiment may give, perhaps, no unjuſt idea of the natural impregnation of Chalybeate waters in the bowels of the earth; and of the manner in which they loſe their peculiar qualities, and depoſite their ferrugineous ingredient, on being brought into a ſtate of leſs confinement.

plentiful; and all the Rammelſberg waters are ſtrongly impregnated with Vitriol. A drop, falling on the clothes, leaves at firſt a ſtain, and in no long time makes a hole. It is little wonder that in ſuch a place vitriolic cryſtals ſhould be formed. In ſundry caverns of the mine, above, below, hanging from the top and ſhooting up from the bottom, we find icicles, of various ſizes, ſome as thick as the arm, curiouſly cluſtered together, like garden beds or grotto-work, white, reddiſh, fleſh-coloured, green, bluiſh green, of a pure blue; affording, eſpecially when viewed by candles, a moſt beautiful ſpectacle.

Preparation of white Vitriol.

At this place the white Vitriol is prepared; from a mixt ore, containing Sulphur, Zinc, Calamine, Copper, Iron, Lead, and other metallic ſubſtances. The ore is roaſted, and elixated with freſh parcels of water; the liquor ſet by to ſettle, then boiled down in leaden pans, and cryſtallized. If the cryſtals have any reddiſh tinge, which they commonly have, they are again calcined, diſſolved in water, the ſolution purified by ſettling, evaporated till it becomes thick, and then poured into moulds. This proceſs is repeated till the matter becomes ſufficiently white. As there is little conſumption for this kind of Vitriol, it is made but ſeldom; ſometimes ſcarcely once in ſix or ſeven years. The ore remaining after the extraction of the Vitriol, is ſmelted as freſh ore. The white Vitriol has hitherto been prepared at Rammelſberg only. It is ſaid that a little begins now to be produced in Hungary.

Converſion of one kind of Vitriol into another.

The vitriolic acid has a greater affinity with Iron than it has with Copper. If vitriol of Copper be diſſolved in water, and ſome clean Iron added to the ſolution, the acid will let the Copper fall, and take up a proportionable quantity of the Iron. The blue colour of the liquor is now changed to a green; and on evaporating and ſetting it to ſhoot, we obtain, inſtead of the blue vitriol of Copper, a green one of Iron. The Copper in this experiment is extricated from the acid in its metallic form, and adheres all over the ſurface of the Iron. If the Iron is in thin pieces, and its quantity duly proportioned to that of the acid, nearly the whole of the Iron will be extracted, and a maſs of Copper of the ſame figure left in its place. Hence aroſe the ancient conceit, of Iron being tranſmuted into Copper by the waters of Neuſol in Hungary; which waters are no other than a natural ſolution of venereal Vitriol. The Copper thus obtained from them is very pure and high coloured: it is commonly called *Cement-Copper*, but might be named, with greater propriety, precipitated Copper.

Blue Vitriol may in like manner be converted into white, by the addition of Zinc; that ſemimetal precipitating the Copper as readily as Iron does. It has been ſaid, that Zinc precipitates Iron alſo from the vitriolic acid, and that green Vitriol may thus be converted into white. But on trial it did not appear that Zinc precipitated any more of the Iron than would have fallen ſpontaneouſly; the ferrugineous ſolution, after digeſtion both with Zinc and with its ore Calamine, yielding ſtill not white but greeniſh cryſtals.

Adheſion of the acid in different Vitriols.

It is obſervable that the adheſion of the acid with the ſeveral metals is not in proportion to its degree of affinity or appetite of union with them, but the very reverſe. Though it readily and totally forſakes Copper upon preſenting to it Iron or Zinc, it is nevertheleſs far more difficultly diſunited by fire from the former than from either of the latter. It is expelled from Zinc the moſt eaſily of the three.

Gold not contained in Vitriols.

There is rarely or never any metallic body beſides theſe in the compoſition of Vitriols; though ſome have imagined that theſe Salts are impregnated with Gold. There are indeed inſtances of a little Gold having ſometimes been extracted from them: but the Gold thus obtained was by no means an ingredient in the Vitriol as ſuch; and had only been caſually embedded in the maſs, as it is in different ſtony and earthy matters in the Gold mines. Thoſe who have been deluded into the moſt ſanguine expectations pections by experiments on a ſingle ſpecimen, have been convinced of this truth upon ſubmitting another parcel to the ſame trials.

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The alchemiſts have expected to find in Vitriol no leſs than an univerſal medicine, and the philoſophers-ſtone. With them the metallic part of the Vitriol precipitated by fixt alcaline Salts, has been eſteemed a ſolar Sulphur, and celebrated as an anodyne of extraordinary virtue. They have treated, by a variety of operations, the cryſtallized Vitriol itſelf, the liquor which remains after its cryſtallization, the rainbow-coloured cuticle which forms upon ſolutions of it; but have always been diſappointed in their aim. The following ſentence, whoſe initial letters compoſe the word *Vitriolum*, has animated them in the purſuit; *Viſita interiora terræ, reperies ibi occultum lapidem, veram medicinam*; that is, "Viſit "the inner parts of the earth, and there you ſhall "find the hidden ſtone, the true medicine." Another ſentence, whoſe initials in like manner make up the word *Vitriolum*, is much more juſt; *Via iſta theſauros requirendo inutilem operam luſerunt viri multi*; "Many "have ſearched for treaſures in that way, and be"ſtowed their labour in vain."

I. VITRIOL *of* IRON.

VITRIOL OF IRON. General properties.

VITRIOL of Iron diſſolves in about twice its weight of water, into a green liquor; and on duly evaporating the ſolution, and ſetting it to ſhoot, concretes again into thick rhomboidal cryſtals. If the cryſtallization is performed in a warm place, the Vitriol commonly riſes up above the liquor, and concretes into efflorescences about the edges of the veſſel. It retains in its cryſtalline form a large quantity of water, amounting to full as much as the metal and acid together. In a warm dry air it loſes a part of its water, and falls by degrees into a white powder.

On

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Changes produced by repeated ſolutions.

On diſſolving the powder or the cryſtals in water, a portion of the Iron is left undiſſolved at the bottom of the veſſel (*d*), in form of a reddiſh yellow or ruſty-coloured calx or ochre. The exſiccated powder leaves conſiderably more of this ochre than the cryſtals. The ſolution depoſites, on ſtanding, more and more of the metal in the ſame form; and being now evaporated yields cryſtals paler coloured than at firſt, with an unctuous liquor, which refuſes to cryſtallize, and which on further evaporation forms a butyraceous maſs that deliquiates in the air. How often ſoever the ſolution and cryſtallization are repeated, a part of the Iron remains always undiſſolved, a part ſeparates ſpontaneouſly from the ſolution, and a part is reduced into a butyraceous matter; the cryſtals being paler and paler till the whole quantity is thus deſtroyed or reſolved. The further the cryſtals are freed from their metal, the more eaſily do they part both with their water and their acid.

Effects of fire.

The cryſtals, expoſed to a gentle fire, liquefy and boil up: and having gradually diſcharged the greateſt part of their water become conſiſtent again, with the loſs of their tranſparency and green colour. The maſs, when it firſt becomes ſolid, appears of a whitiſh colour: on urging it with a ſtronger fire, acid fumes ſucceed the watery ones, the matter becomes yellow, red, and at length of a deep purpliſh red.

Calcination of Vitriol.

It is from this kind of Vitriol, as being the cheapeſt, that the vitriolic acid has been generally extracted for common uſes. The Vitriol is firſt calcined, uſually in

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(*d*) *Spontaneous ſeparation of the Iron from Vitriol.*] A ſolution of the Vitriol in water depoſites, upon ſtanding, a part of its metallic baſis. In length of time, nearly the whole quantity ſubſides, leaving the liquor colourleſs. The precipitation is greatly expedited by a boiling heat; by which more of the metal ſeparates in a few minutes than by ſtanding without heat for a twelvemonth. Upon expoſing the ſolid Vitriol to a moiſt air, a ſimilar reſolution happens on its ſurface; which, in a ſhorter or longer time, according as the Vitriol is more leſs ſaturated with metal, changes its green to an ochery or ruſty hue. Iron does not ſeparate in this manner from any other acid, nor any other metal from this acid.

in Iron pots till it will no longer melt, as its melting in the diſtilling veſſel would endanger burſting it. The calcination is advantageouſly continued alſo beyond this period, as more of the phlegm is thus diſſipated without much loſs of the acid. On collecting the vapours they are found to have very little acidity till the Vitriol has become yellow: from this ſtate to that of redneſs, they prove conſiderably acid. All that ariſes after the matter has become red, is a ſtrong concentrated acid.

Oil of Vitriol.

The diſtillation is performed in earthen longnecks placed in a reverberatory furnace: the makers of Oil of Vitriol in England put fifty or more theſe veſſels into one furnace: to each longneck is luted a glaſs receiver; which, if the Vitriol has been fully calcined, need not be large: the neck of the diſtilling veſſel is introduced into the belly of the receiver, leſt the drops falling on the neck of the glaſs ſhould crack it. The fire is raiſed by degrees, and continued for a certain ſpace of time, uſually ſome days and nights; beyond which, experience has taught the workmen that the produce of acid would not pay the expence of fuel; care muſt be taken, in ſupplying freſh fuel, not to crack the veſſels by admitting cold air to them: a volatile ſuffocating ſmell, like that of burning Sulphur, gives notice of ſuch an accident. If the veſſels will bear a good fire towards the end of the diſtillation, we commonly obtain an highly concentrated acid, in a thick butyraceous form, called glacial Oil of Vitriol: in ſuch caſe we muſt be well upon our guard in taking off the receiver; this concentrated acid, as ſoon as any communication with the air is opened, emitting, in great abundance, ſubtile penetrating fumes capable of ſtriking a man dead.

Its colour whence.

Oil of Vitriol, as firſt diſtilled, appears of a brown or blackiſh colour, which ſome aſcribe to a portion of Iron or Copper brought over with it in the diſtillation. But neither of theſe metals give any ſuch

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Rectification.

tincture to this acid: inflammable ſubſtances do. A ſmall bit of white paper will change the cleareſt Oil of Vitriol, in a little time, quite black. The acid thus tinctured, and that which ariſes coloured from the Vitriol, are both rendered clear by the ſame means, barely by being heated. The phlegmatic acid is rectified by diſtillation in a glaſs retort; the weaker acid or Spirit of Vitriol diſtilling, whilſt the ſtronger, called Oil, remains behind. In this proceſs the retort ſhould be placed, not in ſand, as ſome direct, but in *capella vacua* or an empty iron pot, with only a little ſand ſtrewed on the bottom to keep the retort ſteady: when the glaſs is buried in ſand it is very unequally heated, and hence very liable to crack.

Analyſis of different Vitriols.

One hundred pounds of Engliſh Vitriol, calcined to yellowneſs, were reduced to fifty-five pounds, which yielded fifteen pounds of concentrated oil. From a more exact examination it appeared, that ſixteen ounces of this kind of Vitriol contain above eight of water, one and a half of pure acid, and about ſix of Iron; with a ſmall proportion of Alum, too ſmall to be of any importance. The aluminous matter is moſt diſtinguiſhable in the crude liquor of the pyrites, before it has been made into Vitriol; and in this we may diſcover alſo ſome marks of marine acid: the Vitriol itſelf very rarely participates of that acid in any degree.

The Engliſh Vitriol is purely ferrugineous; but there is ſcarcely any other Vitriol of Iron without ſome admixture of Copper. The Goſlarian, Hungarian, Bohemian, Saxon, Ruſſian, Roman, Saltzburg, French, and Swediſh, are all mixed Vitriols; and in proportion as they abound with Copper contains leſs water and more acid than the pure Vitriol of Iron. Sixteen ounces of Goſlarian Vitriol (the ſort commonly made uſe of in Germany) were found to contain ſeven ounces of water, three ounces of acid, five ounces ſeven drachms and one ſcruple of Iron, and nearly two ſcruples of Copper: in the ſame quantity of another parcel, the water amounted to ſeven ounces and ſix drachms, the acid only to two ounces and two drachms, and the metallic matter to ſix ounces: a third parcel yielded leſs water and more acid. Theſe differences depend chiefly upon the age and dryneſs of the Vitriol, a part of the water being diſſipated in keeping.

The Vitriols which participate of Copper readily diſcover that metal upon rubbing them on a moiſtened bright piece of Iron, which they inſtantly cover with a cupreous coat. It ſeems as if the metallic part of all Vitriols had been formerly ſuppoſed to be Copper only: hence even the ferrugineous Vitriols have, in different languages, received names expreſſive of Copper; by the Engliſh they are called *copperas*; by the Germans, *kupfferwaſſer*; by ſome of the Latin writers *cuperoſum* (i. e. *cuprum eroſum*; by the Greeks χαλκανθος.

Uſe in dying,

Ink.

Green Vitriol ſtrikes a black colour with vegetable aſtringents; and hence is the baſis of the black dye for cloth, leather, hats, &c. The workmen find that the mixed Vitriols anſwer better for theſe purpoſes than the purely ferrugineous; probably from the cupreous part of the Vitriol being more corroſive, more effectually penetrating the ſubject, and thus occaſioning the colouring matter to ſink deeper: the Copper certainly does not contribute to the colour itſelf, for neither the Vitriol of Copper, nor Verdegris, ſtrike any blackneſs with aſtringents: the manufacturers of tobacco are ſaid to make uſe of this Salt for deepening the colour of that commodity. Common ink is prepared from Vitriol and Galls: Bromel tell us that the beſt ink is made according to the old monaſtic verſe, *Uncia ſit gallæ, ſemiſque ſit uncia gummi, Vitrioli pars quarta; his addas octo falerni:* but the liquor thus prepared will not long keep, eſpecially in an open veſſel. To make a black and durable ink, I digeſt ſixteen ounces of bruiſed Galls in two quarts of French white wine for ſeveral days; and then pouring off the wine, gently boil the Galls in two quarts of water: ſix ounces of Goſla-

VITRIOLS. rian Vitriol are diſſolved in this decoction, the wine added to the ſolution, the mixture digeſted for ſome hours, eight ounces of Gum Arabic put in, and when this is diſſolved, a dozen or more of entire Cloves, which in good meaſure prevent mouldineſs. Some add Sugar, others Salt, and others Spirit of Wine, to keep the ink from freezing in winter. From theſe uſes of the Chalybeate, which is the moſt common of the Vitriols, all the ſorts have been called *atramenta*; and minerals impregnated with them *lapides atramentarii*, *atramentſtein*.

Vitriol mixed with Nitre or Sea-ſalt, and expoſed to the fire, extricates the acids of thoſe Salts; the Vitriol firſt parting with its own acid which thus diſlodges the others in the ſame manner as if Oil of Vitriol had been taken. Hence the uſe of Vitriol in the diſtillation of Aqua fortis: the mixed Vitriols are ſaid to anſwer better for this purpoſe likewiſe than the pure Vitriol of Iron: the Engliſh themſelves frequently employ foreign Vitriols in preference to their own (*e*).

Medical uſes.

The medical effects of Vitriol are ſimilar to thoſe of the other preparations of Iron. The pure Vitriol of Iron is here alone to be uſed: the mixed ſorts may be rendered purely ferrugineous, by diſſolving them

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(*e*) *Mechanic uſes of Vitriol.*] In the Swediſh Tranſactions, Vitriol is recommended as a yellow for houſe-painting. Quicklime, made into a paſte with water, is to be diluted with a ſolution of Vitriol, more or leſs according as the colour is required deeper or lighter: the mixture appears of a bluiſh green colour, and does not become yellow till it is dry. One part of Vitriol is ſaid to go as far as two of the dearer yellow Orchre.

This Salt is recommended alſo for preſerving wood, as particularly the wheels of carriages, from decay: when all the pieces are fit for being joined together, they are directed to be boiled in a ſolution of Vitriol for three or four hours, and then kept for ſome days in a warm place to dry. It is ſaid that wood by this preparation becomes ſo hard and compact that moiſture cannot penetrate it; and that Iron nails are not ſo apt to be deſtroyed by ruſt in this vitriolated wood as might be expected, but laſt as long as the wood itſelf.

There are ſome inſtances ſufficiently atteſted of human carcaſes being preſerved for a number of years, in vitriolic mines, free from corruption. In a hiſtory of this kind related in the literary acts of Sweden, all the natural features remained unaltered, though the body had lain forty-nine years: the fleſh was grown of a horny hardneſs.

them in water, and adding ſome bright Iron, which will totally precipitate the Copper; after which the Vitriol is to be recovered by cryſtallization. It is obſervable, that in ſmoking tobacco, a little Vitriol taken into the mouth, leaves, after its aſtringency is over, an agreeable ſweetneſs. —— Externally, this Salt is employed as a ſtyptic, either diſſolved in liquors or calcined. The *ſtypticum heroicum*, as it is called, is compoſed of a pound of Hungarian Vitriol and half a pound of Alum diſſolved in three pounds of phlegm of Vitriol, and mixed, after filtration, with five ounces of Oil of Vitriol. Vitriol calcined to whiteneſs, by the ſun's heat in the dog-days, has been celebrated for ridiculous ſympathetic virtues: Sir Kenelm Digby and others have been ſuperſtitious enough to believe, that it would cure wounds by being applied only to the weapon they were made with, reſtrain hæmorrhages by the blood being dropt upon it, and produce various effects in the body by being put into the patient's urine, *&c.*

VITRIOLS.

II. VITRIOL *of* COPPER.

VITRIOL OF COPPER.

Effects of fire.

THE Vitriol of Copper contains much leſs water than that of Iron, and requires a larger quantity, about four times its own weight, for its ſolution. It does not, like the green Vitriol, part with any of its metal on being diſſolved; nor calcine in the air, or liquefy in the fire. Expoſed to a gentle heat it firſt turns white, and then of a yellowiſh red colour. On urging it with a ſtronger fire the acid ſlowly exhales, and a dark red calx of Copper remains, of a much leſs lively colour, and inclining more to a brown, than the calx prepared in the ſame manner from the Vitriol of Iron. The whole of the acid cannot be ſeparated by diſtillation from either ſort; ſo much acid remaining united with the metal after that operation as to render a part of it ſoluble in water. After this ſoluble part has been extracted, a little acid is ſtill retained, amounting to about one twenty-fourth part of the metallic calx.

Vitriol of Copper is commonly called Cyprian, probably from its having been formerly brought from the iſland Cyprus in the Ægean ſea. Boerhaave makes the Cyprian and Hungarian Vitriols the ſame; but they differ greatly from one onother, the former being a pure Vitriol of Copper, the latter a mixt Vitriol of Iron and Copper.

Preparation.

Vitriol of Copper is never produced by nature without an admixture of Iron. The pure venereal Vitriol is made by art, from cuttings or waſte pieces of Copper, ſtratified and cemented with Sulphur: the cover of the cementing-pot is perforated with one or two ſmall holes, and the cementation continued, with a gentle fire, till the inflammable part of the Sulphur is conſumed: the matter is then boiled in water, and the liquor, after due evaporation, ſet to ſhoot. Such part of the Copper as remains uncorroded, is treated with freſh Sulphur, till the whole of the metal is changed partly into Vitriol, and partly into an indiſſoluble calx. For the inferior kinds of this Vitriol, Pyritæ abounding with Sulphur are ſubſtituted to pure Sulphur. There are few places in which Vitriol of Copper is prepared, the conſumption of this commodity not being very conſiderable.

Medical uſes.

Vitriol of Copper has been recommended in all kinds of intermittent fevers, in the lepra, and when ſaturated with volatile alcaline ſpirits, as a ſpecific in epilepſies. In this laſt caſe I have known it given with very ill ſucceſs, the convulſions being made by it far more violent. Its internal uſe is in no caſe to be ventured on, as it poſſeſſes a truly deleterious quality, in common with the other preparations of Copper: the ſmalleſt portion occaſions a ſickneſs and nauſea; a ſomewhat larger, reaching and violent vomitings, accompanied often with convulſions. If the quantity taken has been conſiderable, and is not ſoon diſcharged by the vomiting, the ſtomach and inteſtines are corroded, intenſe pains, inflammations, and death

VITRIOLS.

death ſucceed. —— Externally, it is uſed as a mild eſcharotic, in ſhankers, and for conſuming proud fleſh; and for reſtraining hæmorrhages. It is applied by the farriers againſt films on the eyes of cattle.

III. WHITE VITRIOL.

WHITE VITRIOL.

THERE have been many different, and for the moſt part erroneous, conjectures about the nature and compoſition of this kind of Vitriol. Boerhaave ſuppoſes it to be no other than Vitriol of Iron exſiccated ſo as to become white. Geoffroy comes nearer the truth, in ſaying it conſiſts of vitriolic acid united with Calamine, or with a a ferrugineous earth and Lead or Tin. Tin however muſt be excluded from the compoſition, as nothing of that metal is diſcoverable either in the vitriol itſelf, or in the ores from which it is prepared.

Analyſis.

Experiment ſhews, that the metallic part of white Vitriol is principally Zinc: when freed from its acid by ſtrong fire it tinges Copper yellow, or changes it into a kind of Braſs, the diſtinguiſhing character of that ſemimetal. It participates alſo of the Iron and Copper, and perhaps of the Lead, with which the ores abound. That it contains Iron appears from the ochery ſediment which ſolutions of it depoſit on ſtanding; and ſtill more evidently, from its yielding, when treated with inflammable fluxes, particles of true Iron to the magnet. Rubbed on a poliſhed moiſt knife, it ſtains the Iron of a Copper colour: Zinc, added to ſolutions of it, throws down a Precipitate, which gives a deep blue tincture to Spirit of Sal ammoniac; plain proofs of its holding Copper.

White Vitriol diſſolves as eaſily as the green, in twice its weight of water. It does not calcine or fall into powder in the air, nor liquefy in the fire. In diſtillation four ounces yielded about an ounce of phlegmatic ſpirit, nearly three ounces remaining in

VITRIOLS. in the retort: the ſpirit, examined by alcaline Salts, was found to contain only half a ſcruple of pure acid to ſeven drachms and fifty grains of water. If the fire had been continued for ſome days longer, more acid would probably have been obtained.

Medical uſes. White Vitriol was given formerly as an emetic, from a ſcruple to half a drachm, two ſcruples, and ſometimes a whole drachm; either in its common ſtate as brought into the ſhops, or purified by ſolution and cryſtallization, when it is called *gilla theophraſti.* At preſent its uſe in that intention is almoſt entirely laid aſide: and indeed it may very well be ſpared as an emetic; two or three grains of emetic Tartar, or a little wine impregnated with glaſs of Antimony, operating as effectually as a drachm of white Vitriol, and with much leſs ſickneſs or uneaſineſs to the patient. Some report, that both the white and blue Vitriols occaſion a ſalivation. This is by no means to be underſtood as a ſalivation ſimilar to that brought on by mercurials, and is no other than a diſcharge of phlegm or water from the nauſea which they excite. White Vitriol is in common uſe externally, in ointments and collyria, againſt heat, inflammations and defluxions of the eyes: ſometimes a little Sugar of Lead is added. It is one of the beſt applications for theſe purpoſes, and I have known it a very lucrative ſecret in particular hands. It is likewiſe a powerful and ſafe errhine, of good uſe in catarrhs, and obſtructions of the noſtrils by indurated mucus: a ſolution of the Vitriol in Marjoram water, is to be ſnuffed up the noſe, or a bit of cloth dipped in it occaſionally introduced. Conſiderable quantities are uſed by the farriers, and thoſe who prepare varniſhes: it is ſaid to promote the drying of varniſhes and oil paints.

ARTICLE III.

Combination of the vitriolic acid with earths.

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Experiments on calcareous earths and vitriolic acid.

THE Vitriolic acid readily and totally diſſolves the aſhes of vegetables into a limpid liquor. Calcareous earths are corroded but not diſſolved by it: with theſe it forms a ſelenitic matter, in appearance reſembling a Salt, but differing from bodies of that claſs in wanting taſte and ſolubility. When the earth is previouſly diſſolved in water it forms with the vitriolic acid a like concrete, which refuſes to diſſolve again: three quarts of Lime-water were ſaturated by ſix drachms of Spirit of Vitriol, of moderate ſtrength; and being then evaporated left near two drachms of this matter in little maſſes like fine flowers of Benzoine. Half an ounce of green Vitriol, diſſolved in water, required for its ſaturation eight pounds and four ounces of Lime-water: the metallic calx, precipitated by the earth of the Lime-water, weighed one drachm and eighteen grains: the liquor filtered and evaporated, left only a drachm and a half of a whitiſh ſomewhat ſparkling concrete. To ſixteen ounces of Quick-lime in ſubſtance, put into water enough to ſlake it, and well ſtirred together, I added by degrees Goſlarian Vitriol till the Lime was ſaturated, and a freſh addition occaſioned no further efferveſcence; three pounds and a half were requiſite for this purpoſe: the matter being now elixated with water, and the liquor evaporated, only one ounce three drachms and ten grains were found to have been taken up by the water: the undiſſolved part weighed when dry, three pounds and nine ounces. The part which the water had diſſolved at firſt would not any longer diſſolve after it had once been ſeparated.

Aluminous earth.

There is another kind of earth, which the vitriolic acid diſſolves with eaſe; and with which it concretes into an aſtringent Salt readily ſoluble in water, called Alum. This earth is commonly ſaid to be chalky;

but

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but I have treated Chalk, Lime, Boles, Lac lunæ, and various other earths with Spirit of Vitriol, without being ever able to produce any Alum. What this earth really is, remains as yet unknown. It does not ſeem to exiſt naturally in the ores from which Alum is prepared, in the ſame ſtate wherein it enters the compoſition of Alum; but to receive its peculiar properties from the calcination and expoſure to the air neceſſary for the production of that Salt. In the ſeveral Alum-ores which I have had an opportunity of examining, there was no mark of ſuch an earth as we obtain from Alum (*f*).

I. ALUM.

ALUM.

Natural hiſtory of Alum.

NATURE produces no perfect Alum, but affords the materials for it in ſundry ores, pyritæ, ſtones, ſlates, earths, waters, and bitumens as pit-coal. The reddiſh Roman Alum is prepared from a reddiſh ſtone found at the bottom of the hill Tolfa near Civita Vecchia in the eccleſiaſtical ſtate: in Sweden and ſome parts of Bohemia Alum is made from Pyritæ and other ores; in England, at Altſattel, and ſundry other places, from bituminous minerals of

(*f*) *Earth of Alum.*] Some later experiments, by Mr. Geoffroy and Mr. Pott, have ſhewn, that the earth of Alum is contained in clay, and that a true Alum may be prepared by digeſting clay in the vitriolic acid. Both theſe gentlemen imagine, that only a particular part of the clay is here extracted. Whether it exiſted originally in the clay, poſſeſſed of the ſame properties which it is found to have when extracted, or whether it has ſuffered a change in the operation, they have not determined. From the experiments I have made, the latter ſeems to be the caſe. Powdered tobacco-pipe clay being boiled in a conſiderable quantity of Oil of Vitriol, and the fire continued to dryneſs, the matter, examined when grown cold, diſcovers ſcarcely any taſte, or only a ſlight acidulous one: on expoſure to the air for a few days, greateſt part of it is found changed into lanuginous efflorescences in taſte exactly like Alum: the remainder, treated with freſh Oil of Vitriol in the ſame manner, exhibits the ſame phænomena, and this repeatedly till nearly the whole of the clay is converted into an aſtringent Salt.—— If the earth be ſeparated again from the acid, (by diſſolving the Salt in water, and precipitating with any alcaline Salt) it is now found to diſſolve with eaſe in every acid; to form with the vitriolic Alum again; with the nitrous, a compound reſembling Alum in taſte; with the vegetable acids, a ſubſtance leſs aſtringent, and leſs ungrateful.

of the pitcoal kind; at Solfatara near Naples, from a whitiſh earth; in Miſnia, from a blackiſh one; at Leowenberg near Freyenwalde, from a reddiſh one; and from different minerals at Saalfeld, Reichenbach, Leuſerſdorff, Suſerſdorff, Eliard, Schwentzel, Duben, &c. There are waters impregnated with Alum, though I have never ſeen any that left a perfect Alum on bare evaporation.

ALUM.

The pureſt and moſt perfect Alum-ore is the reddiſh ſtone of Tolfa: this is ſaid to yield Alum without any additional matter, though not without artificial managements: the Alum obtained from it is tinctured with the reddiſh colour of the ſtone. In its natural ſtate it gives no marks of Alum; and, if expoſed to the air, it continues a hard inſipid ſtone. Calcined or roaſted, and then laid for a time in the air, it becomes by degrees aluminous, and gives out its Alum on being boiled in water. This is the Alum which the Italians call *Alume di rocca*, Alum made from a ſtone or rock: among us, the name *Alumen rupeum*, or rock Alum, is often applied to the larger cryſtalline maſſes, whatever ſubject they have been prepared from.

The aluminous Pyritæ and bitumens require no calcination unleſs they greatly abound with Sulphur. Theſe minerals, as firſt taken out of the earth, are compact, and often bright and glittering: they have no manner of taſte, and diſcover no mark of their holding any thing ſaline; the vitriolic acid being as yet blended with an inflammable matter, by which its acidity and all its ſaline characters are deſtroyed. On bare expoſure to the open air, the inflammable principle is diſſipated, and the acid is combined with the aluminous earth into a perfect Alum, the ſtone at the ſame time falling into powder.

Preparation.

The mineral thus impregnated with Alum, is elixated or boiled with water; the liquor boiled down, commonly with an addition of urine, or alcaline ley, or both together; the clear part poured off and ſet to ſhoot; the cryſtals, if not ſufficiently pure, ALUM. pure, diſſolved again, boiled down with a little more Alcali, and cryſtallized afreſh. The uſe of the urine or alcaline Salt is partly to clarify the liquor and precipitate ſuch metallic parts as it may contain; and partly to give a body to the Alum, and promote the cryſtallization: the liquor of itſelf would not ſhoot, but either continue fluid, or if further evaporated, would yield only an unctuous maſs. Alcaline Salts are found to anſwer better than urine, and hence are now in moſt places alone made uſe of, though ſome ſtill retain urine, from prejudice and cuſtom. The Alcali precipitates not only metallic matters, but a groſs earth which would injure the tranſparency of the Salt; and often alſo a part of the aluminous earth itſelf, which falls to the bottom in form of a fine white meal, called at the works Alum meal: this is to be rediſſolved and cryſtalized afreſh. The mineral remaining after elixation, expoſed for ſome years to the air, becomes impregnated with Alum again; in ſome places this proceſs is repeated a third and a fourth time.

Some earths, as the Alum earth of Solfatara, and the aluminous ſlates, have a manifeſt aluminous taſte when newly dug; and hence are directly elixated, without expoſure to the atmoſphere. In ſome kinds of ſlates we may plainly diſtinguiſh the aluminous matter lying in a powdery form, betwixt the flakes or ſcales of which the ſtone is compoſed. In general, where the mineral holds but little Sulphur, it is ſufficient to lay it for a time in the open air, defended from rain by a a ſhed or ſlight covering: if it participates conſiderably of Sulphur, it muſt be previouſly calcined; if very rich in Sulphur, a part of the Sulphur is firſt extracted by ſublimation, and the reſiduum worked for Alum.

The Alum ſlates near York in England are conſiderably ſulphureous: by lying long in the air, they become aluminous of themſelves, but to promote this effect they are uſually calcined. The boilers are large leaden pans, nine feet long, five feet broad, and

Alum.

and two and a half in depth. The liquor is clarified and diſpoſed to cryſtallize by the addition of Soda, there called Kelp, and of urine. The Alum-ore of Schwentzel near Duben in Saxony, above five miles from Hall, is likewiſe bituminous: this is firſt calcined, then expoſed to the air, elixated with water, and the liquor boiled down with Potaſh. At Altſattel near Carlſbade, the workmen, when I was there, uſed only urine, of which they received conſtant ſupplies from the neighbouring towns and villages. The moſt curious Alum-ore I know of is in Sweden; Sulphur, Vitriol and Alum being here obtained from one mineral, which appears to be a kind of Pyrites. The Sulphur is firſt extracted by diſtillation: the reſiduum being ſtrongly calcined, boiled in water, the liquor duly evaporated and ſet to ſhoot, the Vitriol cryſtallizes. The uncryſtallized liquor, treated with urine and a ley drawn from aſhes, yields Alum.

The cryſtallization of Alum is uſually performed in large ſtrong wooden caſks, whoſe ſtaves and hoops are all marked with numbers, that they may be readily put together: in ſome places Iron veſſels are uſed. The caſks being filled with the Alum liquor evaporated to a due conſiſtence, and ſet in a cold place, the Alum gradually ſhoots into large cryſtals about the ſides: the liquor in the middle is then let off by a cock in the bottom, the head of the caſk knocked out, and the veſſel turned upſide down, for the more effectual draining off of the remaining liquid. The cryſtals are then dried in a warm ſtove, and packed up in caſks; and the mother-ley, or uncryſtallized liquor, mixed with freſh aluminous leys. The metallic or vitriolic Alum-ores occaſion the greateſt trouble; and the Alum obtained from them, though it appears white, is never totally free from ſome metallic impregnation. Conſiderable differences are found in Alum, partly from this cauſe, and partly from its being prepared with urine or Potaſh, or with freſh or ſtale urine: theſe differences are chiefly ob-

ALUM. ſerved by the dyers, and thoſe who prepare lakes for the painters.

General properties. Alum requires about ten times its weight of water to diſſolve in. The ſolution, if the Alum was pure, makes no change in the colour of Syrup of Violets (g); but the common ſorts change the Syrup green, by virtue of the alcaline Salt employed in their preparation. Fixed alcalies, volatile alcalies, and Borax, added to ſolutions of Alum, precipitate the earth. Its taſte is nauſeouſly ſweetiſh and aſtringent. In cryſtallization, it ſhoots into large angular maſſes, conſiſting generally of eleven planes, five of which are hexangular and ſix quadrangular.

Analyſis. An ounce of Alum contains about five ſcruples and a half of earth, one drachm and eighteen grains of vitriolic acid, and nearly five drachms of water. That its acid is the ſame with that of Vitriol and Sulphur, appears from hence, that it forms with metals a true Vitriol; and with inflammable ſubſtances a true Sulphur.—Alum expoſed to the fire, firſt liquefies and boils up like green Vitriol; and when its phlegm is evaporated, forms a white ſpongy brittle maſs. By this treatment it loſes very little of its acid, and hence almoſt totally diſſolves again in water, and ſhoots into hard compact cryſtals as at firſt. The calcined or burnt Alum, as it is called, proves ſharper in taſte than crude Alum, on account of the loſs of its phlegm; and imbibes humidity from the air. Four ounces will, in the ſpace of a month, gain an increaſe of one ounce. Dr. Rhuon expoſed equal quantities of burnt Alum, for equal lengths of time, in a damp cellar, and in a dry upper room; the firſt gained half an ounce, the latter only five ſcruples. If we attempt to extract the phlegm and acid of Alum by diſtillation, we muſt either inject the Alum by

Effects of fire on it,

and of air.

(g) *Alum changes the colour of Syrup of Violets.*] I have not obſerved any ſort of Alum to mix with Syrup of Violets without changing its colour. Common Alum changes violets, cyanus flowers, and other blue flowers and their infuſions or ſyrups, to a purple or red, as acids do; like which alſo it coagulates milk. It deepens ſome watery tinctures of vegetables, as of Madder and Brazil.

by a little at a time into a tubulated retort, or put it into a common retort of which it may fill no more than one half, and apply the fire in ſuch a manner, that the matter may be heated firſt on the ſurface, and thence gradually to the bottom. Though the fire is kept up ſtrong for a conſiderable time, we can ſcarce gain more than half the weight of the Alum, of a phlegmatic ſpirit: the reſiduum expoſed to the air, imbibes moiſture, and then yields more of an acid ſpirit, the phlegm ſerving for a vehicle to the acid. Alum diſſolved repeatedly in vinegar, parts with its water more eaſily than at firſt: it now calcines into a white mealy powder, in a warm room, or by the heat of the ſun. If Alum be deprived of its phlegm by moderate calcination, its acid will be in great part abſorbed by rectified Spirit of Wine: on diſtilling off the ſpirit, and cohobating it ſeveral times on the reſiduum, a *Spiritus vitrioli dulcis* will be obtained.

ALUM.

vinegar.

vinous ſpirits.

Schroder relates, that if the phlegmatic Spirit of Alum be cohobated on the remaining burnt Alum, and this proceſs ſeveral times repeated, the whole quantity of the Alum will at length ariſe over the helm by the heat of a water-bath: but this is directly contrary to experience. There are two preparations of Alum, whoſe names ſeem to imply a change made in its quality or ſome particular matter extracted from it: one is called *Alumen ſaccharinum*, the other *Saccharum*, *manna*, *dulcedo*, and *primum ens*, *aluminis*. If we expect in theſe preparations what their names import, we ſhall be greatly deceived: the firſt is no other than crude Alum ſoftened into a paſte with whites of eggs and roſe-water, and made up into the form of ſugar-loaves; the other is compoſed ſometimes of crude and ſometimes of burnt Alum, made up with common water, Roſe-water, Lime-water, Vinegar, or phlegm of Alum. Some calcine the Alum, then diſſolve it in water, and evaporate the ſolution; and call the Salt thus prepared, *Sal fixum aluminis*; though in no reſpect different from crude Alum.

ALUM.

Black Phoſphorus.

Alum calcined with inflammable ſubſtances, particularly thoſe of the animal kingdom, forms a concrete which takes fire ſpontaneouſly on the admiſſion of air, and which is hence diſtinguiſhed by the name of *Pyrophorus*. This preparation was firſt made publick by Homberg, and uſually bears his name; though, as Geoffroy informed me, Homberg himſelf learnt it from another perſon. The ſame product occurred alſo to me, in making ſome experiments in London, with a different view; and Lemery has given a ſet of experiments expreſsly on the ſubject. The beſt method of preparing this Pyrophorus is, to mix powdered Alum with ſo much yolk of eggs as will reduce it to the conſiſtence of thin honey, and keep the matter conſtantly ſtirring over a gentle fire, breaking from time to time ſuch lumps as may form in it, till the whole is changed into an uniform dry powder. This is to be put into a vial, the veſſel ſlightly ſtopt with paper, ſet in ſand in a crucible over a gentle fire, which is to be gradually increaſed, till the fumes ceaſe, and the matter is moderately calcined: as ſoon as the heat has abated a little, the vial is to be cloſely ſtopt. If a little of this powder be at any time emptied out on a piece of paper, it will preſently take fire and burn like a coal.

Uſes of Alum.

Alum is uſed in large quantity in ſome mechanic buſineſſes; particularly by the dyers, paper-makers, goldſmiths, bookbinders, for preſerving watery liquors from corruption, for preſerving anatomical preparations, and in the embalming of animal bodies: it is far more powerfully antiſeptic than the Vitriols. As a medicine, it is a ſtrong aſtringent, and hence is ſometimes exhibited in hæmorrhages, dyſenteries, and intermittent fevers; but is not to be ventured on in either of theſe caſes, without extreme caution: ſome of the Engliſh phyſicians follow Helvetius's method of mixing the Alum with dragons blood. Externally it is employed againſt inflammations of the eyes, in gargariſms for ſwellings and inflammations of the throat, and for relaxations of the uvula.

II. BITTER PURGING SALT.

Bitter purging Salt.

THIS Salt was originally prepared from the purging mineral waters of Epſom in Surry, and hence is ſtill diſtinguiſhed by the name of Epſom Salt. Dr. Grew publiſhed ſome experiments upon the water and Salt; which occaſioned them to be brought into ſuch general uſe, that the quantity procurable from the ſpring was inſufficient for the demand. Attempts were made to prepare from other materials a Salt of the ſame properties, and with ſucceſs; the analyſis diſcovered by the gentleman above-mentioned, having afforded ſome foundation to proceed upon. Large quantities of the factitious Salts continue to be exported to France, Germany, *&c.* and are ſold at a very cheap rate. The natural waters of Epſom are now little regarded; and, in 1713, I found no perſon there who could give any information about the preparation of the Salt. I inſpiſſated myſelf an hundred quarts of the water, but ſcarcely obtained from them half an ounce of ſaline matter.

Boulduc relates that the Epſom Salt is made by precipitating a ſolution of Alum with Salt of Tartar, and cryſtallizing the remaining liquor. But in this he is manifeſtly miſtaken; for ſuch a proceſs can afford no other than a vitriolated Tartar; whereas the Epſom Salt, and the Salts of the natural purging waters, are ſimilar to the *Sal mirabile*, of which hereafter. After many weariſome enquiries, I found at laſt, that this Salt was prepared in quantity near Portſmouth, from the mother-ley or uncryſtallized liquor left in the purification of the Bay-ſalt imported from Spain and Portugal. The Epſom Salt is compoſed of an alcaline earth combined with vitriolic acid: this liquor contains the earth, combined perhaps in part with marine acid: all that is wanting therefore is an addition of vitriolic acid to diſlodge the marine, and for this purpoſe the Iſle of Wight affords Pyritæ in abundance. The method

PURG. SALT.

that time was, to inſpiſſate the mother-ley, add a portion of the liquor of the pyrites, ſlightly calcine the mixture, and then diſſolve, and cryſtallize the Salt: but probably ſome improvements have ſince been made in the proceſs. I communicated theſe obſervations in the year 1714 to Dr. Lentilius in Holland, who publiſhed them without my knowledge, inaccurately and imperfectly, in the *Ephemerides naturæ curioſorum* (h).

ARTICLE IV.

Combination of the vitriolic acid with alcaline Salts.

VITR. TARTAR.

Its properties.

THE vitriolic acid, ſaturated with vegetable fixt alcalies, forms a bitteriſh neutral Salt, which ſhoots into ſmall hard cryſtals. This Salt is remarkably

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(h) *Bitter purging Salts.*] This Salt, which is now extracted by cryſtallization from the bittern of ſea-water, or the bitter liquor which remains after the culinary Salt has ſhot, is ſometimes ſubſtituted in the ſhops to the cathartic Salt or *Sal mirabile* of Glauber. Some have ſuppoſed the two Salts to be perfectly ſimilar, and indiſtinguiſhable from one another.

They agree in having a bitteriſh taſte; diſſolving in leſs than an equal weight of water; ſhooting into long rectangular priſmatic cryſtals; liquefying in a moderate heat, bubbling up into bliſters, and ſoon changing into a white ſpongy maſs, with the loſs of above half their weight of phlegm, whence the calx taſtes bitterer than the Salts did at firſt; and in their being compoſed of the vitriolic acid united with an alcaline baſis.

They differ in the nature of this baſis; that of the bitter purging Salt being a peculiar kind of abſorbent earth, and that of Glauber's Salt a true fixed alcaline Salt. On adding any alcaline Salt, fixed or volatile, to a ſolution of Glauber's Salt, no change enſues; whilſt the Salts obtained from the purging waters, or from the bittern of marine waters, grow milky or curdly on this addition, and depoſite their earth, the alcaline Salt being taken up in its place. Theſe Salts are therefore truly and eſſentially diſtinct, and very readily diſtinguiſhable, notwithſtanding their agreement in ſome of their more obvious appearances.

The earth of the bitter purging Salt is called *Magneſia alba*; and its principal character is to form with the vitriolic acid a bitter purgative compound. I have no where met with this earth in the mineral kingdom, but in the cathartic Salt itſelf, and in the mothey-ley of Nitre, or the liquor which remains after the cryſtallization of rough Nitre. The earth into which vegetable ſubſtances are reduced by fire (at leaſt the woods and herbs which I examined) is exactly the ſame with this; and probably it is from the vegetable aſhes employed in the preparation of Nitre, that the nitrous mother-ley receives its magneſia. The incinerated earths of animals are of a different kind.

Vitr. Alcalies.

markably ponderous; more ſo than either the acid or the alcali by themſelves, and than any ſaline compound I know of, excepting thoſe which abound with metallic matter, as Mercury-ſublimate. It retains in its cryſtalline form, only a ſmall portion of water. It does not imbibe humidity in a moiſt air, nor become powdery in a warm dry one. It is very difficultly ſoluble in water; being ſcarce at all acted upon by cold, and requiring a large proportion of boiling water: ſpirit of wine, added to the ſolution, precipitates the Salt in form of a white powder like meal. It does not melt in the fire, nor part with any of its acid, nor ſuffer any ſenſible change. Diſſolved in water, it proves in part volatile by the heat in which water boils: by ſtrong continued coction, it may at length be totally diſſipated along with the watery vapour.

Experiments of the ſaturation of th fixt alcalies with vitriolic acid.

Some differences are obſerved in the quantity of the acid and alcali neceſſary for the ſaturation, and in the phænomena attending the proceſs, according as the plain or cauſtic alcali is uſed, and according to the manner in which the mixture is performed. I prepared a cauſtic alcali, by mixing one ounce of pure alcaline Salt with two ounces of Quick-lime, boiling the mixture in freſh parcels of water till the liquor no longer acquired any ſaline taſte, then filtering the ſeveral decoctions, and evaporating them together to dryneſs. The dry Salt weighed two ſcruples and a half more than the alcali employed; and the remaining Lime weighed a drachm leſs than at firſt.

To a drachm of this cauſtic Alcali, rubbed into powder, Spirit of Vitriol was added by degrees, till the Salt was diſſolved and the efferveſcence ceaſed: the quantity of the ſpirit neceſſary for this purpoſe was two drachms. During the efferveſcence, a bright browniſh earth fell to the bottom, which weighed, when dry, three grains: the filtered liquor depoſited in evaporation firſt five grains and a half of white earthy creme, and afterwards five grains of a yellowiſh one: the dry Salt weighed two ſcruples and eight grains. During the ſaturation aroſe an abominable urinous ſmell, from which the exſiccated Salt was not wholly free.

On inverting the order of mixture, and adding the Alcali by degrees to the acid ſpirit, fourteen grains of the former were found ſufficient for ſaturating two drachms of the latter. The ſame kind of ſtench aroſe during the effervescence as in the foregoing experiment, and a blackiſh grey matter fell to the bottom, amounting when dry to fourteen grains: the filtered liquor left on evaporation a dry Salt, weighing half a drachm all but half a grain.

I repeated both theſe experiments with a pure fixed Alcali. A drachm of this required for its ſaturation three drachms of Spirit of Vitriol: the liquor left nothing conſiderable on filtration, and being afterwards evaporated, yielded of dry Salt, partly cryſtalline, four ſcruples wanting one grain.

On inverting the procedure, and taking three drachms of the acid ſpirit firſt, one drachm and nine grains of the pure Alcali were neceſſary for the ſaturation, and half a drachm of a white Precipitate fell to the bottom: on evaporating the filtered liquor, the dry Salt, cryſtals and all, weighed two ſcruples and two grains.

When the alcaline Salts were previouſly diſſolved in water, ſome further differences were obſerved. A drachm of cauſtic Alcali diſſolved in half an ounce of diſtilled water, required for its ſaturation juſt two drachms of Spirit of Vitriol, as the ſame quantity of the Salt had done in its dry ſtate: but no urinous ſmell was here perceived, and a ſcruple of a reddiſh earthy matter precipitated. The filtered liquor evaporated a little, gave eighteen grains of cryſtals, and the remainder inſpiſſated gave ſixteen grains of dry Salt.

On the other hand two ſcruples of Spirit of Vitriol being ſaturated by gradual additions of the cauſtic alcaline ſolution, two ſcruples and eight grains of the Alcali were found ſufficient: during the effervescence,

veſcence, there fell half a drachm of an aſh-grey Precipitate: the filtered liquor gave firſt half a ſcruple of greyiſh cryſtals, and, on being afterwards evaporated to dryneſs, left fifteen grains of Salt.

A drachm of pure fixed Alcali diſſolved in half an ounce of diſtilled water, required to ſaturate it three drachms of the acid ſpirit, and gave no precipitation: the filtered liquor evaporated a little, yielded twenty-two grains of cryſtals, and, on further evaporation, two ſcruples and two grains of Salt. The acid being taken firſt, and the alcaline ſolution added to it, two ſcruples of the Alcali completed the ſaturation; the liquor being filtered and evaporated, eight grains of the neutral Salt fell in form of a Precipitate, twelve and a half cryſtallized, and twenty-ſix remained upon continuing the evaporation to dryneſs.

Different methods of preparing vitriolated Tartar.

The neutral Salt compoſed of vegetable fixed alcalies and the vitriolic acid, is commonly called vitriolated Tartar, and employed in medicine as an aperient and gentle laxative. It was formerly prepared by mixing the diluted acid with a dilute ſolution of the Alcali, ſetting the liquor after due evaporation to cryſtallize, and then further evaporating the remainder to dryneſs: by this method, as the exact point of ſaturation is difficultly hit, the Salt frequently proved too acid; and hence its uſe was by many practitioners laid aſide. Otto Tachenius introduced a method more advantageous to the operator, and by which the medicine may be effectually ſecured againſt a redundance of the acid or the Alcali; inſtead of the acid extracted from Vitriol, he takes a ſolution of Vitriol itſelf: on the addition of an alcaline Salt to this ſolution, the acid of the Vitriol lets fall the metallic part, and unites with the Alcali into the neutral Salt required, which is recoverable from the liquor by filtration and cryſtallization. It was a conſiderable time before this method was received in practice, nor was the foundation of the proceſs known till Stahl diſcovered it. The neutral Salt thus prepared was called a regenerated

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rated Vitriol, and Salt of Vitriol, ſuppoſed by Tachenius, Boyle, and others, to yield its acid in diſtillation in the ſame manner as common Vitriol, to participate of the metallic matter of the Vitriol, whether ferrugineous or cupreous, as well as of the acid. That it may participate of the metal when incautiouſly prepared is certain: hence it frequently occaſioned nauſea, ſickneſs, and even vomiting: Tachenius himſelf gives it the title of *Sal vomitivum.* Theſe inconveniencies depended wholly upon the proportion of Alcali made uſe of being too ſmall to ſaturate all the acid, and conſequently to precipitate all the metal.

To obtain a pure and perfect neutral Salt, the Alcali ſhould be taken in over-proportion; the Vitriol is firſt to be diſſolved in boiling water, and a ſolution of Potaſh or other fixed alcaline Salt gradually added, till the ſaturation appears completed; ſome more of the alcaline liquor is then to be poured in, the whole ſtirred together, the liquor filtered, evaporated till a pellicle appears upon the ſurface, and then ſet to cryſtallize. By this means we are ſecure againſt any metallic taint, and as to the ſuperfluous Alcali it will not cryſtallize; ſuch part of the Alcali as may adhere ſuperficially to the cryſtals is eaſily ſeparated by rinſing them in water. The liquor which remains after the cryſtallization is to be further evaporated, and ſet to ſhoot again: after it will yield no more cryſtals it may be mixed with freſh ingredients when another quantity of the Salt is to be prepared. There is no occaſion for purifying the Potaſh or other Alcali for this uſe, as it will be effectually purified in the proceſs itſelf.

This is the moſt commodious and certain method of procuring a vitriolated Tartar perfectly neutralized, and has another advantage above that in which the diſtilled vitriolic acid is uſed, namely, that the ſubtile volatile ſpirit of the Vitriol, called by Helmont *Gas*, which is diſſipated in the calcination of the Vitriol previous to its diſtillation, is here preſerved. The ſame neutral Salt may be obtained by proceeding in like manner with a ſolution of Alum

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inſtead of Vitriol; or by calcining a mixture of Alum or Vitriol with a ſufficient quantity of alcaline Salt, and elixating the compound with water, the acid being thus transferred from the earth or metal into the alcaline Salt as well as when ſolutions of them are mixed, though with leſs certainty; or by expoſing cloths moiſtened with alcaline leys to the fumes of burning Sulphur; or by melting alcalies with Sulphur, and gently calcining the mixt till the inflammable part of the Sulphur is diſſipated; or by expoſing pure alcaline Salts for a length of time to the air. The neutral Salts obtained by all theſe methods are perfectly ſimilar to one another; the acids of Sulphur, of Vitriol, of Alum, and that which is diffuſed through the atmoſphere, being one and the ſame.

Vitriolated Nitre.

The *Nitrum vitriolatum*, otherwiſe called *Arcanum duplicatum*, *Panacea Holſatica*, *Sal ducis Holſatiæ*, *Sal de duobus*, &c. is no other than a vitriolated Tartar, made with the alcaline baſis of Nitre, which is the ſame with the common vegetable alcalies. This is prepared by elixating with water the matter which remains after the diſtillation of the nitrous acid with Vitriol, the acid of the Vitriol having expelled the acid and united with the Alcali of the Nitre. As the Vitriol, however, after this diſtillation retains a part of its acid, ſo as to diſſolve along with the neutral Salt in water, ſome Potaſh ſhould always be added to abſorb the acid and precipitate the metal.

Sal polychreſt.

The ſame Salt is produced by deflagrating Nitre with a due proportion of Sulphur, the acid of the Sulphur extricating that of the Nitre, and uniting with its alcaline baſis. The Salt thus prepared is called *Sal polychreſtum*, or *Nitrum ſulphuratum*.

Both theſe Salts, though received in the ſhops as diſtinct ones, are found, when made in perfection, to be ſimilar in all reſpects to one another, and to the *Tartarus vitriolatus*. The differences ſometimes obſerved in them are entirely caſual: the *Nitrum ſulphu-*

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ratum may contain a portion of the Nitre unchanged; and both of them, if the Nitre employed particpated of Sea-ſalt, will hold a proportionable quantity of *Sal mirabile*.

Glauber's Salt.

Sal mirabile, ſo called by its firſt diſcoverer Glauber, is a combination of the vitriolic acid with the alcaline baſis of Sea-ſalt. As this Alcali is very different from the common vegetable Alcalies, it forms with the vitriolic acid a different neutral Salt, in taſte more bitter, as a medicine more purgative, eaſily ſoluble in water, and when diſſolved coagulating on the admixture of Spirit of Wine; eaſily fuſible in the fire, and diſcharging a large quantity of aqueous phlegm, calcining by a gentle warmth into a white powder. This Salt is prepared from the matter which remains after the diſtillation of Spirit of Sea-ſalt with Oil of Vitriol or with Vitriol in ſubſtance: it may be obtained alſo from the reſiduum after the ſublimation of Mercury-ſublimate, when Sea-ſalt and Vitriol, or its acid without Nitre, are employed in that proceſs.

Vitriolic ammoniacal Salt.

The vitriolic acid ſaturated with volatile alcalies forms a neutral ammoniacal Salt, called *Sal ammoniacum ſecretum* (i).

(i) *Secret Sal ammoniac, or vitriolic ammoniacal Salt.*] This Salt has a penetrating pungent taſte; and when newly prepared, a ſulphureous ſmell, greater or leſs according as the volatile ſpirit made uſe of was more or leſs loaded with oily matter. It readily diſſolves in water, and increaſes the coldneſs of the liquor: on ſtanding for a little time, it begins to ſeparate from the water, and vegetate or ariſe in efflorescences up the ſides of the glaſs: on moderately evaporating the ſolution, the Salt ſhoots into fibrous plates like feathers. It eaſily melts in the fire, penetrates the common crucibles, and in glaſs veſſels ſublimes unchanged.

On expoſing to the fire a mixture of this Salt with Sea-ſalt, two new combinations happen: the vitriolic acid quits the volatile Alcali, and unites with the fixed alcaline baſis of the Sea-ſalt into a Glauber's Salt; whilſt the marine acid, thus diſlodged from its own baſis, unites with the volatile Alcali, which the vitriolic had forſook, into a common Sal ammoniac. The acid of Nitre is alſo in like manner expelled by the vitriolic ammoniacal Salt. On adding this Salt to a ſolution of any calcareous earth, as Chalk in the nitrous, marine, or vegetable acids, the vitriolic acid forſakes its Alcali to unite with the earth, with which it forms a ſelenitic concrete, which renders the liquor milky or curdly, and, on ſtanding, falls to the bottom: by this mark, the vitriolic is readily diſtinguiſhable from the other ammoniacal Salts, theſe making no change in calcareous ſolutions.

This Salt is called *ſecret* or *philoſophic* Sal ammoniac, from the high opinion, which ſome of the chemiſts have entertained of its activity upon metals. Mr. Pott has given ſeveral experiments on this ſubject in the Berlin Memoirs; from which it appears, that its effects have been greatly exaggerated; that it diſſolves or corrodes in ſome degree all thoſe metals which Oil of Vitriol diſſolves, but has no effect upon thoſe which that acid does not act upon by itſelf.

Gold is not touched in the leaſt, either by the Salt in fuſion or by a ſolution of it: the Salt, added to a ſolution of Gold in Aqua regia occaſions no precipitation or change of colour. On melting the Salt with inflammable matters, it forms a ſulphureous compound, which diſſolves Gold in fuſion, in the ſame manner as compoſitions of Sulphur and fixed alcaline Salt. —— The vitriolic-ammoniacal Salt, melted with Silver, corrodes it into a white calx, which partially diſſolves in water: it likewiſe precipitates Silver from its ſolution in Aqua fortis. —— It acts more powerfully on Copper, elevates in ſublimation a part of the metal, ſo as to acquire a bluiſh colour on the ſurface, and renders greateſt part of the reſiduum ſoluble in water. This ſolution appears colourleſs, inſomuch that it could not be ſuſpected to hold any Copper: it readily diſcovers, however, that it abounds with that metal, by the blue colour which it aſſumes on the addition of volatile alcalies, and the green calx which fixed alcalies precipitate: in evaporation it becomes green, without any addition. The vitriolic acid, in a concentrated ſtate, remarkably deſtroys the colour of cupreous ſolutions: if to a ſaturated blue tincture of this metal in volatile ſpirits, ſome Oil of Vitriol be added, the blue colour will inſtantly diſappear, and the liquor become limpid as water: on adding more of the volatile ſpirit, the colour as readily returns. —— Iron is corroded by the Salt in fuſion, and diſſolved by boiling in a ſolution of it. —— Zinc diſſolves more freely and more plentifully — Lead unites with it, but does not become ſoluble in water — Tin is corroded, and a ſmall portion of the calx diſſolves in boiling water — Of Regulus of Antimony alſo a ſmall portion is made ſoluble: alcalies precipitate from the ſolution a bluiſh powder — Calcined Biſmuth ore, treated with equal its weight of the Salt, partly diſſolved in water into a pale red liquor, which became green from heat, in the ſame manner as tinctures made from that ore by Aqua regia: the undiſſolved part yielded ſtill with fritt a blue glaſs. —— On treating Manganeſe in the ſame manner, aluminous cryſtals were obtained: the undiſſolved part of the Manganeſe gave ſtill a violet-purple colour to Glaſs.

CLASS II.

Nitrous acid and its combinations.

NITR. ACID.

Production.

THE nitrous acid is the moſt limited and leaſt frequent in the earth of all the mineral acids. It is ſeldom met with in any combination but in the neutral Salt from which it receives its name, and ſeems to be in that, rather an artificial than a natural production (ſee Nitre). It is ſuppoſed by ſome to be an offspring of the marine acid, with little probability; for the nitrous acid is more powerful than the marine, expelling it from alcaline Salts and earths, which it is not likely it ſhould do if it received its origin from that acid. Others ſuppoſe it on better foundation to be truly the vitriolic acid, altered by putrefaction, and the commixture of ſome inflammable matter. In proof of this opinion, an experiment is alledged, in which the nitrous acid returns back into the vitriolic: if two ounces of good Spirit of Nitre, and half an ounce of Oil of Turpentine, be digeſted together, a balſam of Sulphur is produced, poſſeſſing all the properties of common balſam of Sulphur. We have already ſeen that Sulphur conſiſts chiefly of vitriolic acid; and whence could that acid be here furniſhed but from the nitrous?

General properties.

The concentrated nitrous acid is weaker and much more volatile than the vitriolic. It is in part diſſipated by the action of the air in pungent vapours, which appear before their diſperſion of a red colour: in diſtillation it ariſes in fumes of the ſame colour. If an unſtopt bottle of this ſpirit, and one containing a volatile alcaline ſpirit, be brought near to one another, the vapours of the two liquors unite together, and form a white cloud in the air. An ounce of the concentrated nitrous ſpirit ſaturates near ſeven drachms of fixed alcaline Salt, and is found to contain about two drachms and a half of pure acid, and five and a half of water.

ARTICLE I.

Combination of the nitrous acid with inflammable ſubſtances.

Heat and flame with oils.

THE nitrous acid mixed with diſtilled oils raiſes a great heat and effervеſcence, and forms with them a thick reſinous maſs like Turpentine. If the acid is highly concentrated and mixed all at once with ſome of the more ſubtile oils, the matter burſts immediately into actual flame (*k*).

With vinous ſpirits.

It raiſes likewiſe a violent ebullition and heat with Spirit of Wine; but this mixture is never obſerved, as ſome have reported, to take fire. The ſafeſt way of mingling theſe liquors is to pour the acid ſpirit by a little at a time into the vinous: if the mixture made with about one part of the Spirit of Nitre to eight of rectified Spirit of Wine be digeſted for ſome days, and then diſtilled in a glaſs retort with a very gentle fire, till only a thick mucilaginous matter remains, the diſtilled liquor diſcovers a grateful ſmell and taſte without any acidity, and hence is called dulcified

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(*k*) *Flame from nitrous acid and oils.*] This experiment does not ſucceed unleſs the acid is highly concentrated, and even when it is, there are few oils which it will fire with certainty, without the obſervance of a particular circumſtance firſt diſcovered by Mr. Rouelle, and communicated in the French Memoirs for the year 1747. On letting fall into the oil equal its quantity of the acid, the mixture effervеſces, ſwells, and a light fungous coal ariſes: a little more of the acid poured upon this coal ſets it inſtantly on fire: by this method almoſt all the diſtilled oils may be fired by Spirit of Nitre of moderate ſtrength. Expreſſed oils alſo may be ſet on fire by a mixture of the nitrous acid with an equal quantity of Oil of Vitriol; the uſe of which laſt ſeems to be to abſorb the aqueous humidity of the nitrous, and thus reduce it to a greater degree of concentration or ſtrength than it can be brought to by itſelf. The other mineral acids raiſe an effervеſcence and heat with oils, but the nitrous is the only one that produces actual flame with them.

The nitrous acid mixed with powdered ice, remarkably increaſes its coldneſs: the marine acid has this effect in a ſomewhat leſs degree, whilſt the vitriolic produces heat with ice.

NITR. ACID.

dulcified Spirit of Nitre. I have often obſerved this dulcified ſpirit vary in quality according to the purity of the acid and vinous ſpirits made uſe of, and the manner of preparation. Some of the dulcified ſpirits have coagulated watery tinctures of the flowers of plants; ſome have weakened or deſtroyed the red colour of the tincture of daiſy flowers, whilſt others produced neither of theſe effects.

With Camphor.

Two ounces of the concentrated nitrous acid diſſolve one ounce of Camphor, the Camphor imbibing the ſtronger acid, and forming with it an oil which floats on the ſurface of the more phlegmatic liquor. Silver added to this ſolution throws out the Camphor, the acid diſſolving the Silver in its place.

Deflagration.

If the nitrous acid be combined with any ſubſtance whatever, that will detain it in the fire ſo as to receive a red heat; on the contact of any inflammable matter in that ſtate it either explodes or deflagrates, that is, burns and flaſhes with a hiſſing noiſe. All inflammable ſubſtances, as bones, hair, &c. and metallic bodies that abound with phlogiſton, occaſion a detonation with this acid, whether added to combinations of it in the fire or diſſolved in the pure acid, and after evaporation urged with a conſiderable heat. The acid is deſtroyed or diſſipated during the deflagration.

ARTICLE II.

Combination of the nitrous acid with metallic bodies.

With metallic ſubſtances.

THE nitrous acid diſſolves or corrodes all metallic bodies except Gold; and this alſo it is enabled to diſſolve by a ſmall admixture of marine acid. Silver, Copper, Iron, Lead, Quickſilver, Biſmuth, and Zinc, are more readily and violently acted upon by this than by any other acid: with Copper it forms a green, with Iron a reddiſh, with Lead a yellow, with the others, colourleſs liquors. Tin it diſſolves imperfectly, and Regulus of Antimony it only corrodes into a powder.

Its action on moſt metallic bodies, unleſs the metal is cautiouſly added by little and little at a time, is accompanied with a conſiderable heat, effervescence, and a copious diſcharge of red fumes, which are found to be the ſtronger and more ſubtile part of the acid. Its action is moſt vehement on thoſe metals which apparently contain moſt inflammable matter; as Zinc and Iron: Calces and croci, or metallic bodies deprived of their phlogiſtic principle it has no effect on. The ſolutions made with it are in general of a bitter and very nauſeous taſte. NITR. ACID.

If Silver be diſſolved in this acid and Mercury added to the ſolution, the acid will depoſit the Silver, and diſſolve the Mercury in its place. If Lead be added to the mercurial ſolution, the Mercury will fall, and the Lead be diſſolved. The Lead in its turn will be thrown down by Copper, the Copper by Iron, and the Iron by Zinc. Volatile alcaline Salts abſorb the acid from all the metals, and fixt alcalies from the volatile. The nitrous acid diſlodges the marine from ſome of the metals, as Regulus of Antimony, but the marine diſunites the nitrous from Mercury and Silver. General affinities.

ARTICLE III.

Combination of the nitrous acid with alcaline Salts.

THE nitrous acid ſaturated with volatile alcalies, forms with them a neutral ammoniacal Salt, which ſeparated from the watery phlegm by cryſtallization, is found to differ remarkably from the other Salts of this kind, in being perfectly diſſoluble in highly rectified Spirit of Wine; and in deflagrating when conſiderably heated, without any addition; eſpecially if the volatile Alcali employed was an oily animal ſpirit: from this property it received the name of *Nitrum flammans*. This acid forms with the alcaline baſis of Sea-ſalt a neutral Salt which ſhoots into With alcalies.

NITR. ACID.

cubical cryſtals, and hence called *Nitrum cubicum.* With vegetable fixed alcalies it cryſtallizes into long hexangular priſms, the common Nitre of the ſhops.

NITRE or SALTPETRE.

NITRE. Of the ancients.

THE *Nitrum* or *Natrum* of the ancients, which was a natural production, appears from the ſeveral accounts given of it, to have been very different from our Nitre. The ſpecimens I have ſeen diſcovered nothing of the peculiar properties of Nitre or its acid, and were no other than Sea-ſalt mixed with a little Alcali, and ſometimes Sal ammoniac and Borax.

True Nitre never native.

Nature affords no perfect Saltpetre: the accounts given by Boerhaave, Lemery, and others, of Nitre being found native in the Eaſt-Indies, of its lying on the ſurface of the ground in open fields ſo as to be ſwept up by brooms, are neither ſupported by any good authority nor conſiſtent with the properties of Saltpetre. This Salt at the time of its firſt production is ſo volatile, that in open fields in thoſe warm climates, the ſun's heat would diſſipate it: how can it ſtand the rains on the ſurface of the open ground? Whence does it receive the vegetable Alcali, which is the baſis of Nitre, and which does not exiſt in the mineral kingdom? We may be aſſured that cryſtalline Nitre, from the Indies, or whence ſoever it comes, has been manufactured by art; that art has ſupplied its alcaline baſis and reduced it into a cryſtalline form. The acid is produced by a natural proceſs, putrefaction; but the Alcali is a creature of art alone: we ſometimes meet with efflореſcences of earthy matters impregnated with the nitrous acid, but very different from true Nitre, and commonly diſtinguiſhed by the names of *Nitrum calcareum*, *Nitrum murarium*, *Aphronitrum*, and *Halinitrum*.

Exiſts not in waters or in the air.

Many have affirmed that a perfect Nitre exiſts in waters, and in the atmoſphere; but experiment diſcovers

covers no ſuch Salt in either. In waters the Sal mirabile, or bitter purging Salt, has been miſtaken for Nitre, from its ſhooting into cryſtals of a ſimilar figure. That thunder and lightning proceed from Nitre is a groundleſs preſumption; and that the firing of gunpowder can impregnate the air with Nitre is apparently falſe; the diſtinguiſhing principle of the Nitre in the compoſition of gunpowder is deſtroyed in the exploſion.

Its production.

For the production of the nitrous acid are requiſite (1.) putrid or putreſcible matters, either of the animal or vegetable kingdom: (2.) certain earths, as lean Clays, Lime-ſtone, Gypſum, the rubbiſh of old buildings, &c. and (3.) air. The putrifying matters afford an oily urinous Salt: the uſe of the earths ſeems to be to imbibe and retain this Salt, whilſt the air ſerves not only as a neceſſary inſtrument of putrefaction, but furniſhes its own vitriolic acid, which being intimately blended with the oily and urinous matter, by means of heat and the motion of putrefaction, is at length converted into nitrous acid.

All animal and vegetable ſubſtances contribute to the production of Nitre, in ſo far as they are ſuſceptible of putrefaction. Animal ſubſtances, as being moſt diſpoſed to putrefy, are for this uſe the moſt proper; and the ſoft and fluid parts more ſo than the ſolid or hard. The greateſt quantities of Saltpetre are produced from urine and dung, whoſe ſtrong tendency to putrefaction renders them preferable to any other matters. Some differences are obſerved in the excrements of different animals: human urine, the urine of ſheep, goats, and horſes, and the dung of pigeons, are found to anſwer beſt. The leaves, flowers, ſtalks of vegetables, hay and ſtraw, ſaw-duſt, &c. are mixed in the compoſition, and contribute more or leſs to the effect according to their degree of putreſcibility. On theſe principles Nitre may be produced in all countries; and in many places very advantageous works might be eſtabliſhed if we were better acquainted with the manner of its production.

Nitrous ferments.

Certain earths may be diſpoſed to this proceſs, and improved ſo as to afford more and more Nitre by the admixture of different ſubſtances which may properly be called nitrous ferments. Lime appears to be particularly ſerviceable in this intention. The following compoſitions are proper. (1.) Lime, ſheeps dung, ſheeps urine, and common Salt. (2.) Lime, Salt, raſped horns and hoofs, cuttings of leather, and other refuſe animal ſubſtances. (3.) Human urine and Lime. (4.) Human urine, Lime, Salt, and pigeons dung, and other like mixtures of Lime and Salt with animal matters. (5.) Compoſitions of vegetables and animals together, as bitter plants boiled in urine and poured on the earth. (6.) Tartar, Lime, and urine. (7.) Lime, preſſings of grapes, and the liquor of dunghills. (8.) Wine lees, dunghill liquor, Lime, and Salt. (9.) Tartar and Lime. (10.) Lime, Salt, dunghill liquor, and the matter remaining after the diſtillation of Spirit of Wine. (11.) Lime, Salt, urine, dung, and martial ſcoria. Theſe compoſitions may be varied, or others formed on the ſame plan, as different circumſtances may require or permit.

Where generated.

A nitrous Salt is produced without much aſſiſtance from art, in places where putrefaction is going on, in grounds frequently trodden by cattle, and impregnated with their excrements, where vegetables rot, about ſlaughter-houſes, lay-ſtalls, and in burying-grounds, on old ſhady walls expoſed to putrid vapours, as thoſe of ſtables, pigeon-houſes, privys, near dunghills, *&c.* The earths into which the putrid matter moſt readily inſinuates itſelf for the production of Nitre, are rather of the lean than the fat clayie kind, as mud-walls, Lime-ſtones, and other abſorbent ſtones. Some of the Saltpetre-makers, when they have met with an earth fit for the purpoſe, ſpread it in the neighbourhood of putrifying matters, where it may receive the putrid vapours.

The earth is of no further uſe in this proceſs than as a matrix to imbibe and retain the nitrous matter: it contributes no more to the production of Nitre than alcaline Salts to the production of the water which they attract from the atmoſphere. Though Sea-ſalt promotes the proceſs, it does not appear to furniſh any material principle to the Nitre, and ſeems to be of no further uſe than as it haſtens putrefaction. The aerial acid intimately blended with putreſcent exhalations in the pores of ſpongy ſtones or earths, is, ſo far as we can judge, the true parent of the nitrous acid.

Imperfect Nitre.

The nitrous matter thus produced is by no means perfect Saltpetre. It is diſſipated from the earths by the ſun's heat; and hence Nitre-works are commonly made to face the North, and the largeſt quantities of nitrous matter are found on the North-ſides of walls. It exhales upon ſtrongly boiling the earths in water. Extracted by water it does not cryſtallize; the liquor gently evaporated leaves only an unctuous ſaline maſs, which liquefies again in the air. With inflammable ſubſtances it deflagrates much more languidly than true Nitre. To convert this volatile or calcareous into a perfect Saltpetre, by ſubſtituting a pure fixed alcaline Salt to the impure volatile or earthy matter here combined with the acid, is the buſineſs of art.

Extracted and made perfect.

In moſt of the German Nitre-works, a mixture of two parts of aſhes of hard wood and three of Quicklime is ſtratified with the nitrous earth, in large wooden caſks, the cock at the bottom being kept clear from the earth by a baſket or ſome ſtraw placed round it. The veſſel is filled up with hot water, the liquor, after ſtanding for ſome time, drawn off, freſh water added, and this repeated ſo long as it extracts any ſaline taſte. The elixated earth is expoſed again for ſome years to the action of the air and putrid exhalations, and thus becomes again impregnated with Nitre. Some, inſtead of intermixing the Lime and aſhes with the earth, ſprinkle an alcaline ley upon the earth before its elixation, or mix it with the ley

drawn

drawn from the earth. In ſome places the nitrous ley of the very firſt running is ſo weak, that it is neceſſary to uſe it inſtead of water for a freſh tub of earth.—The liquor is gently boiled down to a due conſiſtence, and then ſet to cryſtallize, the ſcum which ariſes during the boiling being occaſionally taken off. The workmen judge of the proper conſiſtence for cryſtallization, by a little of the liquor poured on a cold Iron quickly congealing; and of its being ſufficiently ſaturated with the alcaline addition, by the dry matter quickly deflagrating on a burning coal. The liquor which remains after the cryſtallization is further evaporated and ſet to ſhoot again: when nothing more will ſhoot, it is poured upon freſh nitrous earths, or employed for the preparation of Magneſia, of which hereafter.—Trial has been made of alcaline Salts by themſelves, and of Lime by itſelf; but neither of them ſucceeded ſo well as a mixture of the two, either for forming Nitre with the nitrous ley, or with the pure nitrous acid alone. Lime alone does not cryſtallize; with alcalies alone, the cryſtals prove ſmaller and of a ſharper and leſs agreeable taſte than when Lime is added.

Purification, &c.

Saltpetre is at preſent prepared and refined in almoſt all countries, not only in the Eaſt-Indies, but in ſeveral parts of Europe, as Muſcovy, Poland, Sweden, Denmark, England, France, Bohemia, Germany. The Nitre produced at different works differs in degree of purity; it has naturally an admixture of the Sea-ſalt employed in the compoſitions from which it is made: oftentimes a quantity of Alum is fraudulently mixed. It is purified by ſolution in water, filtration, and cryſtallization: the pure Nitre ſhoots firſt, the Sea-ſalt and other heterogeneous matters remaining diſſolved: ſome add to the ſolution a little alcaline ley or Quick-lime; others a ſmall portion of Alum, which occaſions the cryſtals to be larger. For fire-works the Nitre is diſſolved in Vinegar, whoſe inflammable matter is ſuppoſed to promote the detonating power of the Nitre. In the arſenal at Paris, Saltpetre is refined to different degrees of purity: of this manufacture a pretty full account is given by Lemery.

Marks of its purity.

The purity of Saltpetre is commonly judged from the cryſtals being large and long, colourleſs, tranſparent, free from knots or protuberances, and from their crackling when held in the warm hard. Cubical cryſtals are a mark either of common Salt itſelf, or at leaſt that the nitrous acid is combined with the Alcali of common Salt inſtead of a vegetable Alcali. Their crackling or flying about when laid on a burning coal is a more certain mark of Sea-ſalt, and their ſwelling up into bliſters after burning, of Alum. Some require the Nitre to burn totally away, and look upon ſuch as leaves any reſiduum to be impure; but the pureſt Nitre leaves always a reſiduum, though we ſeldom find much remaining upon the coal, greateſt part of it ſputtering about and running off. The purity is moſt ſatisfactorily determined by rediſſolving and cryſtallizing the Nitre, and comparing the firſt and laſt cryſtals together; and by examining what kind of ſpirit they afford.

General properties.

Pure Nitre (1.) diſſolves in leſs than ſeven times its weight of water. (2.) It has a cooling taſte, and increaſes the coldneſs of water in its diſſolution. (3.) It melts with a leſs degree of heat than moſt of the other Salts, and flows thin as water. (4.) It bears a melting heat for a conſiderable time without loſing any of its acid, but at length parts with a little, as appears from its growing moiſt on expoſure to the air, its alcaline principle now prevailing: the whole quantity of the acid, however, can ſcarcely be expelled, or not without a very long continuance of intenſe fires with frequent alternations of cold. (5.) It does not take fire of itſelf how ſtrongly ſoever it is heated, but immediately deflagrates on the contact of inflammable matter, whether vegetable, animal, or mineral. (6.) It does not deflagrate with fluid ſubſtances till their aqueous part is evaporated. (7.) It deflagrates with the imperfect metals and ſemimetals, NITRE. diſſipates their phlogiſton, and changes them into a calx. It is the true teſt of inflammable matters, extricating and burning with the inflammable principle wherever it is to be found. (8.) In the act of deflagration the acid of the Nitre is deſtroyed; the vapours which exhale are urinous, and the matter which remains is the fixed alcaline Salt of the Nitre. (9.) Inflammable ſubſtances are incapable of themſelves of burning without air: by the addition of Nitre they burn in vacuo. If the air, however, is ſo perfectly exhauſted as that the coaly matter will not catch the fire, the Nitre in ſuch caſe will not kindle it. (10.) Nitre froths up greatly in the fire on the admixture of fixed alcaline Salt or Borax, particularly the latter. (11.) In diſtillation its acid ariſes in deep red, garnet-coloured vapours. (12.) Though produced by putrefaction, it reſiſts putrefaction the moſt powerfully of all the Salts. It gives a red colour to animal fleſh.

Uſes. The principal conſumption of Nitre is in the making of gunpowder, and in compoſitions for fireworks: for this laſt uſe, the workmen have a commodious method of reducing large quantities into a powder, called Saltpetre meal, by diſſolving it in a little water, evaporating the ſolution, and keeping the matter conſtantly ſtirring with a wooden ſpatula during the exſiccation. This Salt is employed alſo in the refining of metals, in dying, in the compoſition of the coloured glaſſes, for heightening and calling forth latent colours, for preſerving proviſions, and ſundry other mechanical and œconomical uſes.

Nitrous Salt in vegetables, whence. The dungs which improve the fertility of land, ſeem to produce that effect by virtue of the nitrous matter generated from them by the air. Wherever we meet with a true nitrous Salt in vegetables, we may be ſure that the plant has grown in a rich-dunged field, on nitrous walls, or other nitrous ſoils; for ſuch a Salt is by no means natural to vegetables, though not unfrequently found in them. In fields there are ſometimes lumps of dung left unſpread:

the plants which grow on thoſe ſpots ſhall be impregnated with a nitrous Salt, whilſt others of the ſame kind, growing in an undunged part in their neighbourhood, ſhall have none. We often obſerve theſe differences in fumitory, tobacco, particularly its ſtalks, the plants which grow on walls, and the thatch of houſes, *&c.*

Medicinal preparations.

There have been many preparations of Nitre contrived for medicinal uſe, but pure Nite itſelf is preferable to them all, and has a better claim to the title of a polychreſt Salt than any, either of its own preparations or of thoſe of other Salts. See Stahl's *Menſis martius, de uſu Nitri medico polychreſto.*

Infuccated

Some diſſolve Nitre in vegetables juices, infuſions, or decoctions, and cryſtallize it afreſh: the Nitre thus *inſuccated* as it is called, is diſtinguiſhed by the name of the plant whoſe juice, *&c.* has been uſed; *Nitrum roſatum, violatum, papaveratum, hordeatum,* &c. Such preparations are at beſt unneceſſary; for if the Nitre is ſuppoſed to retain any thing of the vegetable, the advantage expected from thence may be obtained with greater certainty by exhibiting an infuſion or other ſuitable preparation of the vegetable along with the Nitre. When diſſolved in the juices of ſaline plants, as that of ſorrel, the Nitre will evidently retain a portion of the eſſential ſalt of the herb, and in this caſe is called *Nitrum eſſentificatum:* but here alſo it is ſurely more adviſable to mix the pure eſſential Salt with a certain determinate quantity of pure Nitre.

Chalybeated.

The *Nitrum cabeclicum,* or *Nitrum chalybeatum,* is a mixture of Nitre, *Arcanum duplicatum,* and Vitriol of Iron, diſſolved and cryſtallized together.—*Nitrum nitratum,* or *Draco fortificatus,* is made by adding Spirit of Nitre to a ſolution of Nitre, in the proportion of about half an ounce of the ſpirit to an ounce of the Salt, or diſſolving the Salt in the acid ſpirit, and then cryſtallizing. Some cohobate the acid ſeveral times upon the Nitre.—*Nitrum regeneratum,* or *Tartarus nitratus,* is prepared by ſaturating ſpirit of Nitre with fixt alcaline Salt, and cryſtallizing the neutralized liquor.

Nitrated.

Regenerated.

The

NITRE. The Salt thus prepared is ſomewhat ſharper than common Nitre: boiled for ſome time in a Tin veſſel, it ſenſibly corrodes the Tin; an effect never obſerved from common Nitre: by the addition of Lime, or rediſſolution in Lime-water, it loſes this acrimony, and becomes indiſtinguiſhable from pure Nitre.

Sal prunellæ. *Nitrum tabulatum*, *præparatum*, *ſulphuratum*, *Rotula nitri*, *Cryſtallus mineralis*, *Lapis* or *Sal prunellæ*, is made by melting a quantity of Nitre in a crucible, and injecting upon it, when in thin fuſion, ſome flowers of Sulphur, in the proportion of about a drachm to an ounce of Nitre: when the deflagration is over, the fluid matter may be taken up with a tobacco-pipe or other like inſtrument, and dropt upon a Copper-plate ſo as to form it into little cakes. The Sulphur ſhould be injected by a ſmall quantity at a time: ſome uſe Sulphur in the maſs, and throw in a whole piece at once, but I have ſeen dangerous conſequences from this practice.——In this proceſs, the acid of the Sulphur expels a part of that of the Nitre, and unites with a proportionable quantity of the Alcali into a vitriolated Tartar; ſo that the preparation is no other than a mixture of Nitre and vitriolated Tartar in uncertain proportions, different operators employing different quantities of Sulphur. Where a mixture of theſe Salts is wanted, the rational preſcriber will never direct ſuch a precarious compoſition, whilſt the two Salts are to be had ſeparately, and may be readily mixed together in ſuch proportions as he ſhall think fit.

Arcanum duplicatum. The *Arcanum duplicatum*, *Sal catholicum*, *ſapientiæ*, *antifebrile*, *de duobus*, *&c.* is compoſed of the Alcali of Nitre and the acid of Vitriol, remaining after the diſtillation of the nitrous ſpirit with Vitriol or its acid. (See p. 320.) The alcaline baſis of Nitre differs from the common alcaline Salt made from Tartar, only in having a ſmall admixture of calcareous earth. We have formerly ſeen that the acid of Vitriol forms with this earth a concrete not diſſoluble in water, and which conſequently cannot be retained in the preparation;

ſo that the *Arcanum duplicatum* appears from its compoſition, as well as from experiments made upon it, to be entirely the ſame with vitriolated Tartar.

NITRE.

Sal polychreſt.

A combination of the Alcali of Nitre with the acid of Sulphur is commonly called, from ignorance of its real nature, *Sal polychreſtum.* This is prepared from equal parts of Nitre and flowers of Sulphur mixed together, injected by degrees into a red-hot crucible, kept in the fire for ſome time, when grown cold elixated with water, filtered, evaporated and cryſtallized. A Salt prepared in the ſame manner from equal parts of Nitre, Sulphur, and cryſtals of Tartar, is ſaid by Senac to be the Sal polychreſt of Seignette. Monſ. Petit has given ſeveral curious experiments of the vegetation or efflorefcences of theſe kinds of Salts in their cryſtallization.

Antimoniated Nitre.

The *Nitrum antimoniatum* or *anodynum minerale*, is a neutral Salt obtained by cryſtallizing the firſt waſhings of diaphoretic Antimony (p. 209). It is ſo extremely uncertain in quality, that the phyſician can never truſt to it, being ſometimes an *Arcanum duplicatum*, or Sal polychreſt, ſometimes a mixture of that Salt with unchanged Nitre, impregnated more or leſs with the reguline part of the Antimony. We may readily diſtinguiſh its containing Nitre, by its deflagrating on burning coals. This Nitre may be diſtinguiſhed from pure Nitre by grinding a little of it in a mortar with Alum or Vitriol, when the antimoniated Nitre will immediately yield a ſmell of Aqua fortis, which the common Nitre does not; or by diſſolving it in water, and adding ſtrong Spirit of Vitriol, which will precipitate a white reguline powder from the antimoniated Nitre, but throw down nothing from the pure.

Fixed Nitre.

The *Nitrum fixum* is the fixt alcaline Salt of Nitre, freed from its acid by deflagration with inflammable matters, and purified by ſolution in water, filtration, and evaporation. As vegetable coals deflagrate with Nitre more readily and more freely than the moiſter animal fats or other like matters, thoſe are made choice of

NITRE. of for this operation. Some melt the Nitre firſt in a crucible, and gradually inject upon it powdered Charcoal, till a freſh addition occaſions no further deflagration upon ſtirring the matter: others invert the procedure, injecting the Nitre upon the ignited Charcoal; and others grind both the ingredients together, and inject the mixture into a red-hot crucible: this laſt method ſeems to be the beſt. The perfect alcalization of the Salt depends chiefly on the due proportion of the Charcoal to the Nitre; for if this is not hit, a part of the Nitre will remain unchanged. Three parts of Nitre are commonly directed to one of Charcoal; but if the Charcoal is good, ſix or ſeven parts of Nitre will not be more than ſufficient, and the Nitre will be more perfectly alcalized than if its proportion was leſs. It is very difficult to deſtroy the acid by one operation ſo effectually as that the remaining Salt ſhall not yield red nitrous vapours on the affuſion of Oil of Vitriol: hence Hoffman was led to affirm, that fixt Nitre differs from the common fixed Alcalies. When fully alcalized, it is in all reſpects the ſame, and yields like them, not red but white fumes with the vitriolic acid. A part of the acid of the Nitre ſeems, in the deflagration, not to be diſſipated or volatilized, but fixed and converted into an Alcali: fixteen ounces of pure cryſtalline Nitre conſiſt of about eight ounces of water, four ounces of pure acid, and four of Alcali: if this quantity of the Salt be deflagrated with three or four ounces of Charcoal, which ſcarcely yield four or five grains of Alcali, eight, ten, and if the operation is carefully performed, even twelve ounces of pure alcaline Salt will be obtained.

Extemporaneous Salt of Tartar.

Nitre deflagrated in the ſame manner with Tartar, is reduced likewiſe into an alcaline Salt, which here receives an addition from the Alcali furniſhed by the Tartar. When the Nitre and Tartar are taken in equal quantities, nearly all the Nitre is alcalized, and a white Salt remains, called extemporaneous Salt of Tartar: if the quantity of the Nitre is double to that of the Tartar, great part of the Nitre continues undeſtroyed: on the other hand, if the quantity of Tartar is double or treble to that of the Nitre, all the Nitre is deſtroyed or alcalized, but great part of the Tartar is converted only into a black coal, the Nitre being inſufficient to burn out all its inflammable matter. This laſt compound is the common reductive Flux for metals among the chemiſts, goldſmiths, aſſayers, *&c.* and diſtinguiſhed from its colour by the name of black flux: the coal of the Tartar ſupplies the inflammable principle neceſſary for the revival of metallic calces: and the Alcali furniſhed by the Nitre promotes their fuſion. Both the black Flux and the white Salt are commonly prepared by grinding the Nitre and Tartar ſeparately into powder, then mixing them together, and ſetting them on fire in an Iron mortar, without applying any other heat than that which ariſes from their own deflagration. It is remarkable in this proceſs, that though both the ingredients ſeparately yield an acid ſpirit, yet here no marks of acid are to be perceived, the vapour which exhales being of the urinous kind; and that though Tartar, when calined by itſelf to whiteneſs, leaves, on being diſſolved in water, a very conſiderable quantity of earth, yet, when thus burnt white by Nitre, it almoſt totally diſſolves, leaving ſcarcely any earth at all. The elder Geoffroy ſeems to claim the diſcovery of a volatile urinous ſpirit being produced from Nitre and Tartar, in the French Memoirs for the year 1717; but the ſame obſervation was made by Stahl thirty years before.

Black flux.

Nitre is alcalized likewiſe by deflagration with metallic ſubſtances: by the martial Regulus of Antimony it is rendered not only alcaline, but exceſſively cauſtic, whence its name *Nitrum cauſticum.* A like effect is produced alſo, but in a lower degree, by filings of Iron, by Tin, and other mineral ſubſtances, whoſe phlogiſton is fixed or intimately combined in the compoſition of the ſubject. Schroder reports that Nitre is alcalized by Quick-lime, but on trial

Cauſtic Nitre.

NITRE. trial this did not happen. For preparing the *Nitrum cauſticum*, nothing more is required than to mix the Nitre and martial Regulus in fine powder, and cement them for a time together.

Magneſia alba. *Magneſia alba* (ſo called in diſtinction from the plain *Magneſia* or Manganeſe, which is employed in the making of Glaſs) is a white very ſubtile powder, prepared from the mother-ley, or the liquor which remains after the firſt cryſtallization of rough Nitre. It was introduced as a medicine about fifty years ago, by Count di Palma at Rome, and continued a very lucrative ſecret. Sundry other preparations different in colour, yellow, brown, and violet *Magneſia*, were likewiſe vended in oppoſition to it.——This celebrated medicine appears to be no other than a calcareous earth impregnated with a minute portion of the nitrous and marine acids, and to have very little claim to the virtues commonly aſcribed to it. That the mother-ley contains thoſe acids is evident from its yielding, when exſiccated and diſtilled with Oil of Vitriol, an Aqua regis. The matter diſſolved in them appears to be chiefly the Lime that had been added in the extraction of the Nitre: if an alcaline Salt has been employed for this purpoſe without Lime, no Magneſia will be obtainable from the mother-ley. If the mother-ley is inſpiſſated to dryneſs, and then calcined, greateſt part of the acids is expelled: on edulcorating the calx with water, the ſmall portion of Nitre or Sea-ſalt that might have been retained, is waſhed off, and little other is left than the mere calcareous earth: this is the celebrated Magneſia. If common Quick-lime, ſlaked, dried, and ground into fine powder, be moiſtened with a little Spirit of Salt and Spirit of Nitre, then calcined and edulcorated, the ſame Magneſia will be obtained as that produced from the mother-ley. Hoffman propoſes a more expeditious and commodious method of preparing the Magneſia from the mother-ley than that above-mentioned, by precipitation with Oil of Vitriol, Oil of Tartar per deliquium, or Spirit of

Sal ammoniac; the Precipitates however, obtained by theſe three liquors, will not be entirely the ſame (*l*).

Terra foliata nitri, &c.

The *Terra foliata nitri* is made from alcalized or fixed Nitre ſaturated with Vinegar, in the ſame manner as the *terra foliata tartari* from Salt of Tartar.—The *Nitrum ammoniacale fixum* of Wedelius is prepared by injecting one part of powdered Sal ammoniac upon four of melted Nitre.—A mixture of four ounces of Nitre, a drachm and a half of Borax, a drachm and a half of Sal ammoniac, and a ſcruple of flowers of Sulphur, injected gradually into a red-hot crucible, is called *Nitrum antifebrile*.

Spirit of Nitre.

Having now gone through the ſolid preparations of Nitre, we proceed to the fluid; the principal of which is the acid ſpirit. Nitre committed to diſtillation by itſelf flows in the retort like water, and does not give over any ſpirit. The antient chemiſts, ſuppoſing the extrication of the acid to be prevented by the fuſion of the Salt, mixed with it certain earthy matters to divide or diſcontinue its particles, and thus prevent its fuſion. To one pound of Nitre they took ſix or eight pounds or more of red Bole or Loam, diſſolved the Nitre in water, worked up the powdered earth with this ſolution, and formed the mixture into balls about the ſize of pigeons eggs: theſe were dried in a warm place, put into earthen retorts, and diſtilled in a reverberatory furnace. An acid ſpirit now aroſe, but commonly weak and in ſmall quantity: on elixating the reſiduum with water, it was found that

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(*l*) *Magneſia alba.*] Magneſia alba differs from calcareous earths in two remarkable properties. One is, that it is not convertible by fire into Quick-lime, the true criterion of earths of the calcareous kind: the other, that it diſſolves readily in the vitriolic acid, into a limpid, bitter, purgative liquor, whereas calcareous earths concrete with that acid into an inſipid and indiſſoluble ſelenites, and all the other earths that diſſolve in it form auſtere ſtyptic compounds. As conſiderable quantities of Lime are mixed with nitrous earths previouſly to the elixation of the Nitre, the earth obtained from the mother-ley may often contain a portion of calcareous earth, or even conſiſt almoſt wholly of that earth: whence probably our author was miſled into the opinion of this earth being no other than the calcareous. The earth which makes the baſis of the purging Salts of mineral waters, and the incinerated earths of vegetables, are a pure Magneſia. See page 294.

NITRE. that only a little of the Nitre had given out its acid, the greateſt part being recoverable in its original form, and having ſuffered no reſolution or ſeparation of its principles. The Nitre thus recovered, diſtilled with freſh earth, yields more ſpirit; and the Nitre, which then remains unchanged, treated again in the ſame manner, affords more, till the whole quantity of the Salt is thus reſolved. The earth, on the other hand, which has once been uſed, though perfectly freed by water from all remains of the Salt, if mixed a ſecond time with Nitre, will never extricate any more of its acid; a proof that the expulſion of the acid depends not upon the diviſion or diſcontinuation of the Nitre, for the earth divides it now as effectually as at firſt, but on ſome particular matter in the earth, which it loſes in the firſt operation. The white earths, as Chalk, Lime, calcined bones, tobacco-pipe clay, *&c.* extricate no acid from Nitre even on the firſt time of uſing.

Stahl was the firſt who diſcovered the true theory of this operation. All the earths which extricate the acid of Nitre contain vitriolic acid; and it is on this acid that the effect wholly depends. Hence Vitriol itſelf, as containing much more of the acid, is employed to far greater advantage. If equal parts of Nitre and of green Vitriol, calcined to yellowneſs, be committed to diſtillation, the whole of the nitrous acid will ariſe. It has been generally ſuppoſed that the acid of the Vitriol comes over in this proceſs along with that of the Nitre; and hence the diſtilled ſpirit is called, not Spirit of Nitre, but Aqua fortis. This, however, is by no means the caſe, the ſpirit, if the ingredients have been duly proportioned, being purely nitrous: all the vitriolic acid remains united with the alcaline baſis of the Nitre, and forms therewith the neutral Salt called *Arcanum duplicatum*, or vitriolated Tartar. It is a diſtinguiſhing character of the vitriolic acid to diſlodge both the nitrous and marine from any kind of alcaline Salt, and to unite with Alcali in their place. (Aqua fortis.)

NITRE.

The makers of Aqua fortis in Holland uſe for the diſtilling veſſel a large Iron pot with an earthen head and receiver, and keep the receiver cool by a conſtant application of cold water. —— They commonly employ rough Saltpetre without purification; and as Saltpetre in this ſtate almoſt always participates of Sea-ſalt, the nitrous ſpirit receives from thence a proportionable admixture of marine acid. The Eaſt-India Saltpetre is ſeldom free from pepper-corns, ſtraws, and other vegetable matters, by which the Aqua fortis is further fouled. When uncalcined Vitriol is uſed, ſome part of its volatile phlegmatic acid, haſtily extricated at firſt, will ariſe without acting upon the Nitre; and if the Vitriol is taken in a larger proportion than the nitrous Alcali can ſaturate, a part of its concentrated acid will diſtil towards the end of the proceſs. Hence Aqua fortis as commonly prepared is very ſeldom pure, as is well known to the refiners, who ſeparate Silver from Gold by means of this acid. — Pure Aqua fortis or Spirit of Nitre perfectly diſſolves Silver into a colourleſs tranſparent liquor: a moſt minute portion of the marine or vitriolic acids added to this ſolution, renders it milky, extricating a part of the Silver, which on ſtanding falls to the bottom along with the extraneous acid. Hence we are furniſhed with a ſure method of diſtinguiſhing whether Aqua fortis participates of thoſe acids, and of purifying it from them. A little ſolution of Silver made in the pure nitrous acid, is to be dropt into that which is to be examined: if any milkineſs or cloudineſs enſues, we may be certain that the Aqua fortis is impure: if on ſtanding till the milkineſs has ſubſided, another drop of the ſolution occaſions no freſh cloudineſs, we may be equally ſure that the impurities are now ſeparated. Solution of Mercury likewiſe precipitates the marine acid from Aqua fortis in the ſame manner. Theſe experiments are a further proof that perfect Aqua fortis, ſuch as will diſſolve Silver, is no other than

a pure

NITRE. a pure Spirit of Nitre, ſince the nitrous acid mixed with either of the others will not diſſolve it.

Some diſtil the nitrous ſpirit with Alum inſtead of Vitriol, taking two parts of burnt Alum to one of Saltpetre, Others have uſed the dilute acid ſpirits previouſly extracted from Vitriol or Alum: of theſe, no proportions can be fixed, as the ſpirits differ greatly in degree of ſtrength; if the nitrous ſpirit obtained by this means is found to participate of the vitriolic acid, it is purified by drawing it over again from a little freſh Nitre, which will retain that acid; if it proves too phlegmatic, it is concentrated by diſtillation without addition, the watery part ariſing firſt, and the ſtronger acid remaining behind. The Spirit of Nitre prepared both by Alum and by the pure vitriolic acid, emits red fumes in the air like that obtained by means of Vitriol; a proof that theſe vapours are not owing, as Lemery ſuppoſes them to be, to a Sulphur imbibed from the Vitriol, or to any metallic impregnation.

The ſtrongeſt ſpirit of Nitre is obtained moſt commodiouſly by means of the concentrated Oil of Vitriol. Pure dry Nitre, reduced into powder, is put into a tubulated retort placed in Sand, a large receiver cloſely luted on, and ſome Oil of Vitriol poured in by a little at a time, through the tube of the retort, which is to be cloſely ſtopped after each addition. A part of the nitrous acid will ariſe without the application of any heat: after the ſpontaneous vapours have ceaſed, the fire is to be augmented by degrees till nothing more will come over. This ſpirit is extremely ſtrong, ſubtile and volatile, and requires to be well ſecured from the air, otherwiſe its more active parts will ſoon be diſſipated. It is diſtinguiſhed by the names of *Spiritus nitri concentratus*, *Volatilis*, *Fumans*; *Glauberi*, from its inventor Glauber, though Boyle alſo claims the diſcovery; and *Flammificus* or *Inflammans*, from its ſetting ſome eſſential oils on fire when haſtily mixed with them. Hoffman has given ſome experiments of this kind in his *Obſervationes phyſico-chymicæ*: and the younger Geoffroy in the French Memoirs.

Clyſſus.

Five parts of powdered Nitre and three of powdered Sulphur, mixed together and injected by a little at a time into a tubulated retort furniſhed with a recipient, yield a mixed acid ſpirit, compoſed of the nitrous and vitriolic acids. This is called *Clyſſus*; and when Antimony is uſed inſtead of Sulphur, *Clyſſus antimonii.* They are both of them very inſignificant preparations, and not worth the making. The vitriolic acid may be ſeparated, and the ſpirit rendered purely nitrous, by drawing it over from a little freſh Nitre.

Nitrous ſpirit by vitrification.

Blue ſpirit of Nitre.

In all the foregoing diſtillations, the nitrous acid is expelled from its alcaline baſis by the more powerful vitriolic. There are methods of extricating the nitrous without the intervention of that acid: if Nitre and ſand be mixed together and urged with a ſtrong fire, the Alcali will let go the acid, unite with the ſand and melt with it into Glaſs. Arſenic alſo expels the acid of Saltpetre: the ſpirit obtained by means of this concrete differs ſurprizingly from all the others in an exceſſive degree of volatility, and a deep blue colour. See page 218.

CLASS III.

Marine acid and its combinations.

MARINE ACID.

THE marine acid, ſo called from its being diffuſed through the waters of the ocean, and making a conſtituent part of the neutral Salt ſo plentifully extracted from them for culinary uſes, is ſuppoſed by the chemiſts to be an offspring of the primordial or vitriolic acid, and to conſiſt of that acid combined with an inflammable and a mercurial or arſenical principle.

General properties.

This acid is ſtronger than any of thoſe of the vegetable or animal kingdom, but weaker than the vitriolic or the nitrous, diſlodging the former from alcaline

MARINE ACID.

line Salts and earths, but being itſelf diſlodged from them by both the latter. In the moſt concentrated ſtate in which we can eaſily collect it from other bodies, it contains about ſeven drachms of water to one of pure acid. It is in part diſſipated by the action of the air in pungent vapours, not of a red colour like thoſe of the nitrous acid, but white. It ariſes in diſtillation alſo in white fumes, which condenſe upon the ſides of the recipient in ſtriæ like Spirit of Wine.

ARTICLE I.

Combination of the marine acid with metallic bodies.

As a menſtruum of metals.

THE marine acid eaſily diſſolves Zinc, Iron, and Copper. It acts more difficultly on Tin, and ſcarcely acts at all in its liquid ſtate, though aſſiſted by a conſiderable heat, upon Silver, Mercury, Lead, or Regulus of Antimony. There are means, however, of combining it with all metallic bodies: thus, when a pure acid is abſorbed from the phlegm by fixed alcaline Salts, and the phlegm evaporated, if the dry Salt be committed to the fire in a proper veſſel, with the addition of vitriolic acid, the marine acid will be extricated from the Alcali in highly concentrated vapours, by which all the metals except Gold are diſſolved or corroded. It diſſolves Gold by the aſſiſtance of the nitrous acid, in its liquid ſtate (*m*). —— It diſſolves metallic bodies when calcined, or deprived of their phlogiſton by fire, in which ſtate the nitrous acid has no effect upon them. The metallic matter from which the coloured earths and ſtones receive their colour, is likewiſe extracted by this acid.

Liqueſcibility of its combination with metals.

All the combinations of metals with this acid are eaſy of fuſion in the fire. There are few which concrete into

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(*m*) *Diſſolves Gold.*] The marine acid diſſolves Gold alſo without the aſſiſtance of any other acid. If the Gold is melted with Tin or other imperfect metals, and the mixture calcined, or if the Gold is reduced into the form of a calx, this acid, by moderate digeſtion, will perfectly, though ſparingly, diſſolve it, and keep it permanently ſuſpended. See page 48.

into a cryſtalline form: all but thoſe of Silver, Mercury, and Lead, if exſiccated by heat, imbibe moiſture from the air, and run into a liquid ſtate. The compound which it forms with Silver is not diſſoluble in water; that with Lead is ſcarcely ſo, and with Mercury difficultly: with Regulus of Antimony it forms a butyraceous or liquid matter, from which the metallic part is ſeparated and thrown to the bottom upon diluting it with water. Its combinations with moſt of the other metallic ſubſtances are eaſy of ſolution, not only in water but in rectified Spirit of Wine.

Volatilizes metals.

The marine acid, when combined with metals, very ſtrongly adheres to them, ſo as not to be expelled by any degree of fire: in a ſtrong fire, it either volatilizes or carries them through the crucible, but never parts from them without the intervention of ſome other matter. Gold itſelf is ſo far ſubtilized and volatilized by this acid, as to ſublime and diſtil over the helm. Silver and Lead are reduced by it into concretes fuſible as wax, ſemitranſparent as horn, and ſo volatile that by a moderate fire they may be all driven up the chimney. Biſmuth and Regulus of Antimony diſtil with it in a butyraceous form, and Tin in that of a fluid ſmoking ſpirit. Iron ſublimes with it into yellow flowers.

Affinities with different metals.

Though the marine is weaker than either of the other mineral acids, it has a greater attraction to ſome of the metals, particularly the white ones, to moſt of which it diſcovers a particular affinity: thus Silver, Mercury, Lead, it precipitates from their ſolutions made in other acids; but on Gold, Copper, or Iron, it has no ſuch effect.

The metals which it thus abſorbs from every other acid, are not thoſe to which it diſcovers the greateſt appetite of union when no other acid intervenes: in this circumſtance it will unite with Copper, Iron, or Zinc, in preference to any of the other metallic bodies. When combined with Mercury, if Silver be added to the compound, and a moderate fire applied,

it

MARINE ACID.

it will let the Mercury go and corrode the Silver. If this compound be melted with Lead, the acid will be transferred into the Lead, and leave the Silver revived into its metallic form. It will quit the Lead for Regulus of Antimony or Tin; and either of theſe for Copper, which it diſſolves into a green liquor. If Iron be added to this ſolution, the acid will let the Copper fall, and diſſolve the Iron in its place; and in like manner it will part from the Iron to diſſolve Zinc. —— Such are the general laws of its affinity; but there are circumſtances in which it recedes from them. When Sea-ſalt and Vitriol of Iron are mixed together and committed to the fire, the vitriolic acid forced out from its metal by the heat, extricates the acid of the Sea-ſalt, and this laſt unites with the Iron which the other has forſaken: ſo far the general laws of affinity obtain. The exception is, that if Quickſilver be added to this mixture, the marine acid, inſtead of uniting with the Iron, will unite with the Mercury; and yet, when combined with the Mercury, it will forſake that to unite with Iron. The event is the ſame when Vitriol of Copper is ſubſtituted to Vitriol of Iron, or Regulus of Antimony to Quickſilver.

ARTICLE II.

Combination of the marine acid with alcaline Salts.

I. COMMON SALT.

COM. SALT.

THE common alimentary Salt, called emphatically *Salt* without any epithet, is ſuppoſed by ſome to be the *Sal indum* of the ancients: but the accounts which the ancients have given of the *Sal indum* are evidently repugnant to this opinion: they deſcribe it as being in colour like Salt, and in taſte ſweet as honey; from whence it plainly appears to have been no other than our ſugar, the name *Saccharum* or *Zuccharum* being of much later date.

Common Salt is found either diſſolved in the water of the ocean, or in thoſe of certain ſprings, or in a ſolid form in the bowels of the earth; whence the names *Sal marinum* or Sea-ſalt, *Sal fontanum* or ſpring Salt, and *Sal foſſile* or foſſile Salt: this laſt is called alſo, from its being found in hard tranſparent bright maſſes like Cryſtal, *Sal gemmæ*. All the ſorts are entirely natural Salts, art doing no more than to extract them from the waters, or purify them from the heterogeneous matters with which they are intermixed; whilſt Nitre, Alum, Vitriol, and other mineral Salts owe to art, in good meaſure, their original production.

COM. SALT. Different kinds.

It has been diſputed whether the ſea or the foſſile Salt were created firſt; ſome ſuppoſing the foſſile Salt to have proceeded from the ſea-water left in caverns of the earth at the time of the deluge; and others, that the ſea-water became ſaline only at that period, by diſſolving the foſſile Salt. It is probable that both ſorts were created in the beginning: the immenſe beds of rock Salt met with in the earth have no appearance of their having been left there by the evaporation of water: and on the other hand, that the ſea was originally ſaline may be judged from the Moſaic account of the creation; whales and other ſea fiſhes were created on the fifth day, and it is not to be ſuppoſed that theſe could ſubſiſt without Salt to the time of the flood.

which firſt produced.

Sea-water contains different proportions of Salt in different climates, not entirely, as ſome have imagined, from its being in ſome places more diluted than in others by freſh rivers running into it; but principally from the greater or leſs heat of the climate, and proportionable evaporation of the aqueous parts. A pound of ſea-water in the northern part of the Baltic, particularly in the *Sinus Bothnicus*, yields ſcarcely a quarter of an ounce of Salt: further ſouth, from the mouth of the Elbe to Holland, and in the Britiſh channel, a pound yields an ounce: in the Mediterranean and Spaniſh ſeas, the ſame quantity of water holds two ounces, and probably, towards the Line, the

Quantity of Salt in Sea-water.

COM. SALT.

the proportion of Salt will be found greater. Boyle obſerves, that the water at the bottom of the ſea is more ſaline than at the ſurface.

Bay Salt, where and how prepared.

The beſt Sea-ſalt and the greateſt quantities, are prepared in Spain and Portugal, as at Almahada, near Cadiz, St. Lucar, Malaga, St. Ubes. Conſiderable quantities are made alſo in France, and the Engliſh have attempted to eſtabliſh a Salt-work at Minorca. The general method of ſeparating the Salt is by evaporating the water; and the advantageouſneſs of the manufacture depends upon the effecting of this without the expence of fuel. For this purpoſe, choice is made of a clayie ground near the ſhore, ſo ſituated as that the ſea-water may be occaſionally let in or out by proper canals and ſluices: the ground being overflowed in the beginning of ſummer, to a ſmall depth, the water gradually exhales by the heat of the ſun, and leaves the Salt behind in a cryſtalline form. An account of the Salt-works in France may be ſeen in Lemery (*n*). The impure

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(*n*) *Salt from the evaporation of ſea-water by the ſun's heat.*] Dr. Brownrigg propoſes a ſimilar proceſs in the Britiſh dominions. He ſhews, that commonly almoſt twice as much water falls annually on the weſtern as on the eaſtern coaſts of England; that in Lancaſhire, there does not fall in May, June, July, and Auguſt, above one third the quantity that falls during the reſt of the year; that in theſe months, at leaſt thirty inches will exhale, and only ten inches fall; that in exceeding hot weather, an inch will evaporate in twenty-four hours; that on the evaporation of ſixteen inches of ſea-water, there will remain one hundred and twenty-eight grains of Salt on every ſquare inch, and 104544 pounds on an acre. He directs the ponds to be made in a row from Eaſt to Weſt, and fitted with covers of ſail-cloth ſtretched on frames and painted white: theſe ſerve both to keep out rain, and in dry weather to reflect the ſun's heat. The brine in the firſt large reſervoir may be occaſionally forced up by a fire engine, with a diverger, to make it fall in drops. The expence of this apparatus, he obſerves, will be much leſs than that of the common ſaltern, excluſive of the fuel, which often coſts more than two-thirds the value of the Salt.

At Lymington, ſea-water is concentrated by the ſun's heat ſo advantageouſly, that though afterwards boiled with Newcaſtle coal, the Salt can be afforded cheaper than that made in the neighbourhood of Newcaſtle itſelf, where the fuel is not above one fourth the price.

Salt from ſea-water by fire.] The brine is boiled down in large pans made of Iron plates, joined with nails, and cemented with Lime. From a pan of about 1305 gallons are drawn every day fifteen or twenty buſhels of Salt, each buſhel containing fifty-ſix pounds. In Northumberland impure blackiſh-grey Salt thus obtained is exported from Spain and Portugal, to England, Holland, Sweden, and many other parts of the world, under the name of Bay-ſalt: this is refined by the Engliſh and Dutch, by ſolution in a little water, clarification commonly with ſome oxe's blood, and evaporation continued till the Salt forms into grains: in this refined ſtate likewiſe it proves an article of extenſive commerce. The Salt made in France is chiefly conſumed in France itſelf, and without purification, ſuch an extravagant duty being laid upon it, that people of middling circumſtances cannot afford a refined Salt.

Sea-water concentrated by cold.

The more northern nations, Denmark, Norway, Sweden, *&c.* where the ſun's heat is inſufficient for the preparation of Sea-ſalt by the method abovementioned, might avail themſelves of their natural cold, by which greateſt part of the ſuperfluous water will freeze

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Northumberland and Durham there are upwards of two hundred pans at work, in which are annually prepared eleven or twelve thouſand tuns of Salt.

To the brine juſt warm are added the whites of three eggs, or a little ox blood, mixed with two or three gallons of ſea-water. As the heat increaſes, a black ſcum ariſes, which is raked off, and the liquor now perfectly clear, kept ſtrongly boiling: an earth called ſcratch, ſubſides into ſmall pans placed for that purpoſe in the corners of the boilers, where the motion is moſt gentle. When cryſtals begin to form on the ſurface, the pan is filled up, clarified afreſh, and this repeated four times. When the Salt now begins to cryſtallize, the fire is ſlackened, and the liquor kept only ſimmering during the granulation. After the Sea-ſalt has cryſtallized a bitter liquor remains, which on further evaporation yields the bitter purging Salt, page 293.

Common Salt has one remarkable property, in which it differs from all the other neutral Salts. It diſſolves almoſt as plentifully in cold as in hot water; if water be fully ſaturated with it when boiling hot, ſcarcely any of the Salt ſeparates or cryſtallizes upon the liquor's growing cold. The Salt concretes only in proportion as the water evaporates, and hence the neceſſity of keeping up the heat during the whole time of the cryſtallization . . . . If the proceſs is too long continued, the bitter Salt cryſtallizes along with the culinary Salt. We ſeldom meet with any Sea-ſalt entirely free from the bitter one: hence the earthy matter, which ſolutions of Sea-ſalt depoſit upon the addition of alcalies, and which ſome have erroneouſly looked upon as one of the conſtituent parts of the Sea-ſalt itſelf.

There is another ſingular property of common Salt, its parting with a conſiderable quantity of its acid, on boiling down, whether in open or cloſe veſſels, a ſaturated ſolution of it to dryneſs. Hence the acid which ariſes in the diſtillation of ſea-water, eſpecially towards the end of the proceſs; and hence the alcaleſcent quality of Sea-ſalt cryſtallized by too ſtrong a heat, its diſpoſition to liquefy in the air, its weakneſs and unfitneſs for preſerving proviſions.

COM. SALT. freeze, leaving a ſaturated ſaline ſolution, from which the Salt may be ſeparated with little expence of fire.

The point in view in theſe operations, is, to diſſipate the water and preſerve the Salt: it were to be wiſhed we could equally ſeparate the Salt and preſerve the water, ſo as to obtain from the ſea a ſweet water, fit for drinking and the other uſes of life. Sundry methods have been propoſed for this purpoſe, but none have hitherto fully ſucceeded: I have ſeen many machines and models of machines, which anſwered in ſome reſpects, but failed in others. See *Water.*

Bittern. The mother-ley of Sea-ſalt, or the liquor which remains after the purification and cryſtallization, is employed in England for making a purging bitter Salt, which proves ſimilar in quality to the Salt obtained from the Epſom waters, and is commonly ſold under its name. The ley is boiled down to a certain pitch, then filtered and inſpiſſated, the dry matter calcined, rediſſolved, and cryſtallized. (See page 293.) If the mother-ley be inſpiſſated, and diſtilled with vitriolic additions, a Spirit of Salt is obtained.

Sal gem. The foſſile Salt or Sal gem is found in ſeveral parts of Europe, as in Poland, in Spain, particularly in Catalonia, in Muſcovy, in Calabria, in Tranſylvania, and at Stower in the upper Hungary. Some of theſe Salt mines are of amazing magnitude: the ſingle mine of Cracow in Poland, near Wielizka and Bochna, is computed to hold Salt enough to ſuffice the whole world for many thouſand years. There are houſes, chapels, *&c.* under ground, all built of Salt or the Salt ſtones. The foſſil is cut and turned into pillars, altars, crucifixes, images, *&c.* oftentimes it is naturally cryſtallized into very curious figures. Maſſes are brought up to day, weighing from twenty to thirty hundred weight. The pure ſaline maſſes are called *Stone-ſalt*, the harder and more ſtony, *Salt-ſtones.* Pieces of theſe laſt are commonly put into cow-ſtalls for the cattle to lick, as they hold longer than the Salt. In Poland, Tranſylvania, and Hungary, the mineral is commonly white or greyiſh: in Catalonia, it is often reddiſh, bluiſh, and of various other colours. The pure cryſtalline pieces are employed for the common purpoſes of Salt in their natural ſtate: the more impure and crumbly are purified by ſolution in water, filtration and cryſtallization: they do not now concrete into maſſes of the original ſize, though the cryſtals are ſomewhat larger than thoſe of ſea or Spring-ſalt.

Spring-ſalt

The Spring-ſalt is the ſort generally made uſe of among us, and underſtood by the name common Salt. The Salt-ſprings of different countries are impregnated with different proportions of Salt, and the Salt itſelf differs alſo in degree of ſtrength. The brine at Halle is one of the richeſt in Germany; a pound of this contains three ounces and three drachms of Salt, while ſeveral others hold ſcarcely a quarter of an ounce upon a pound (*o*). On the other hand the Lunéburg and Hartzeburg Salt, and ſome others, are ſtronger and better, and ſhoot into larger cryſtals than that of Halle. An account of the ſalt-works at Halle may be ſeen in Hoffman's obſervations; and an account of moſt, if not all the places in Europe where Salt is boiled, or foſſile Salt dug, in the Breſlau collections.

In the boiling of the brine, ſome ox's blood is commonly added to promote the ſeparation of the impurities, which ariſe with the blood to the ſurface of the liquor, and are thence ſcummed off: ſome beer is added to promote the granulation or cryſtallization of the Salt: wine anſwers the ſame purpoſe, and rectified Spirit of wine ſtill more effectually. The cryſtals are firſt formed on the ſurface, but, growing gradually larger from the accretion of freſh matter, they ſink to the bottom, from whence they are

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(*o*) *Quantity of Salt in ſaline ſprings.*] Several brine-pits in England are richer in Salt than thoſe above-mentioned. Thoſe of Droitwich contain four ounces on ſixteen; and ſeveral pits at Northwich, and at Barton in Lancaſhire, no leſs than ſix upon ſixteen; which is as large a proportion of Salt as water will diſſolve. The Droitwich brine is ſaid to be pure from ſcratch, and ſcarce to hold any bittern, whilſt all others contain both.

are taken up with wooden inſtruments, and put in baſkets to drain.

Concentration of ſaline water by air.

In ſome places where the brine is ſo dilute that the quantity of Salt would not pay the expence of fuel neceſſary for the evaporation, and where neither the ſun's heat nor froſt can be applied to advantage, a method has been contrived of concentrating the liquor, or diſſipating great part of the ſuperfluous water, by means of air and wind: large buildings are erected open every way to the air, with ciſterns and channels, where the brine is conſtantly dripping, or falling in ſlender ſtreams, through bundles of ſtraw, horſe-hair, faggots, *&c.* A part of the water being thus carried off, the reſt is evaporated by fire. There are works of this kind at Nauenheim near Francfort, at Saltzungen, Aſcherſleben, Allendorff, Saltza, Hellen, Saltzgutter, near Lutzen in Merſeburg, near Colberg in Pomerania, and in ſeveral other places. The proceſs however is not a little troubleſome and incommodious. The ſtrength of the brine is judged of by the hydrometer, or by weighing equal meaſures of the brine and of common water. Diſtillation, rediſſolution, and cryſtallization are the ſureſt teſts, but require too much time and trouble to be practiſed at the works.

Chemical properties of common Salt.

Pure common Salt diſſolves eaſily in leſs than thrice its quantity of water, into a clear colourleſs liquor, which depoſits no ſediment: on gentle evaporation the Salt concretes into cubical cryſtals, hollow at top, pointed at bottom, hard, compact, colourleſs, and tranſparent: the ſoft, crumbly kinds, and ſuch as grow moiſt in the air, are inferior in ſtrength to the ſolid. Laid on burning coals, it crackles, burſts in pieces and flies about, increaſes the flame, and is in part diſſipated. It eaſily melts, and at the ſame time loſes a little of its acid, the Alcali being now found to prevail ſo much, that the Salt liquefies in the air. It is eaſily volatilized by fire, and by putrefaction along with ſubſtances diſpoſed to that proceſs. By repeated ſolutions and calcinations, it may be totally deſtroyed or converted into earth: by thirteen repetitions of theſe operations, a pound of Salt was reduced to half an ounce, the earth amounting to three drachms, and the Salt that remained unchanged only to one.

Differences of ſea, brine, and foſſile Salts

The three ſorts of common Salt appear, when perfectly pure, to be one and the ſame, but in their common ſtate ſome little differences may be obſerved in them. The ſea and Spring-ſalts never ſhoot into ſuch large and ſolid cryſtals as the Sal gem: the cryſtals of the Spring-ſalt are the ſmalleſt of the three, and likewiſe the weakeſt. Sea-ſalt frequently contains a little nitrous matter, produced from the putrefaction of vegetable or animal ſubſtances in the ſea; hence the acid ſpirit extracted from it is ſometimes obſerved to diſſolve Gold, which the marine acid is incapable of doing without the aſſiſtance of the nitrous. Alcaline Salts added to a ſolution of the ſea or Spring-ſalts, render the liquor turbid or milky, and precipitate an earthy matter, amounting to about ten grains, from an ounce of Sea-ſalt, and twelve grains from the ſame quantity of Spring-ſalt; added to a ſolution of Sal gem, they occaſion no precipitation or turbidneſs.

Spirit of Salt different methods of diſtilling.

The acid of common Salt is extracted in the ſame manner as that of Nitre, either by the addition of a more powerful acid, which may diſlodge it from its fixed alcaline baſis, or of vitreſcible earths, as ſand, with which in a ſtrong fire, the Alcali melts into Glaſs, letting go its acid. The firſt of theſe methods is the only one practiſed, the latter being extremely troubleſome and incommodious. Both the vitriolic and the nitrous acids expel the acid of common Salt: the firſt is preferred, as being the moſt powerful, and as a part of the nitrous acid would ariſe with the marine, and thus inſtead of a pure ſpirit of Salt, produce an Aqua regia.

The old method of diſtilling ſpirit of Salt was with red Bole, ruddle, or other coloured bolar earths: theſe were moiſtened with a ſtrong ſolution of the Salt into the

COM. SALT.

the conſiſtence of a paſte, then formed into little balls, the balls dried and diſtilled in earthen retorts: the ſpirit thus obtained was in ſmall quantity, and very phlegmatic. It was endeavoured to be freed from the redundant phlegm by rectification, or rediſtillation in glaſs retorts; but the great volatility of the marine acid renders it incapable of being concentrated to any conſiderable degree by this method, the acid vapours ariſing in part along with the water.

The earths in the foregoing proceſs, as in the diſtillation of Spirit of Nitre, were of no further uſe than as they were impregnated with vitriolic acid: and hence ſubſtances participating more largely of that acid were employed to much greater advantage. Calcined Vitriol readily and effectually extricates the acid of the common Salt, but one of the peculiar qualities of the marine acid renders it an improper addition; this acid, when diſunited from its own alcaline baſis, adhering ſo ſtrongly to the metallic part of the Vitriol, as ſcarce to be elevated in diſtillation. Alum is free from this inconvenience: the common Salt may be mixed with thrice its weight of Alum moderately burnt, and the mixture committed to diſtillation in glaſs retorts in an open fire: the diſtilled ſpirit may be drawn over from a little freſh common Salt, which will abſorb and keep down any of the aluminous or vitriolic acid that may have ariſen in the firſt diſtillation. But the marine ſpirit is moſt ſpeedily and effectually ſeparated by oil of Vitriol itſelf; and the ſpirit obtained by this means is the ſtrongeſt and moſt concentrated: it is ſo ſubtile and volatile, that its vapours will ſcarce condenſe in the recipient, and can ſcarce be confined by any luting, its ſmell being diffuſed throughout the whole elaboratory: hence it is adviſable to place in the recipient ſome ſpirit of Salt already made, with which the fumes may incorporate. The moſt commodious method of performing the proceſs, is to put the Salt into a tubulated retort, and drop in the oil of Vitriol through the aperture of the tube by a little at a time: if much of the Oil was poured in at once, the fumes would ariſe ſo haſtily and copiouſly as to endanger ſuffocating the operator; and if poured in by the mouth of the retort, it would be apt to foul the neck. In all the diſtillations, the ſudden ceſſation of the white clouds, or the receiver growing clear before the ſpirit has come over, are marks that the retort has cracked.

Uſe of Spirit of Salt.

Spirit of Salt has been employed by ſome for cleaning and whitening the teeth. A French prieſt, father de Cabriere, gave it in ruptures, and vended it as an extraordinary panacea, to the prejudice of the health of many, eſpecially thoſe who had weak lungs. An empyric, Mœbius, vended a liquor by the name of *Tinctura aperitiva*, which, as Hoffman and Barchuyſen aſſure us, was no other than ſpirit of Salt, tinged with turnſol or roſes, and abated a little of its acidity by a ſmall admixture of Salt of Tartar: the quantity of the alcaline Salt is ſaid to be only half a drachm, or at moſt a drachm, to a pound of the ſpirit of Salt; a notable arcanum truly! Spirit of Salt in its corroſive ſtate, is by no means fit for internal uſe.

Dulcified Spirit of Salt.

This acid is dulcified like the other mineral acids, by Spirit of Wine. One part of Spirit of Salt is commonly mixed with three parts of highly rectified Spirit of Wine, the mixture digeſted and diſtilled: but as ordinary Spirit of Salt is very phlegmatic, and as phlegmatic acids are unfit for dulcification, we ſeldom meet with a good dulcified Spirit of Salt in the ſhops. The beſt method of obtaining ſuch a ſpirit is, to place the Spirit of Wine in the receiver, in the diſtillation of the ſmoking Spirit of Salt with Oil of Vitriol: by this means we obtain a mixture of the concentrated marine acid with the inflammable ſpirit, which are afterwards to be more perfectly combined together by digeſtion and diſtillation. Three or four ounces of the vinous ſpirit may be taken to every ounce of common Salt.

Regenerated Sea-ſalt.

Spirit of Salt ſaturated with Salt of Tartar, yields on cryſtallization a neutral Salt called regenerated Sea-ſalt. This is of a ſharper taſte than common Salt itſelf, and differs from it in ſome other reſpects, the alcaline baſis of common Salt being different from the alcaline Salt of Tartar, or any of the vegetable alcalies. When the nitrous acid is poured upon common Salt, the marine acid will be extricated, and readily diſſipated by heat, the nitrous remaining combined with the Alcali of the common Salt, with which it ſhoots into cubical cryſtals, whereas with the common vegetable alcalies it forms long hexangular priſms. Oil of Vitriol combined in like manner with the marine Alcali, forms a neutral Salt which eaſily diſſolves in water, and eaſily melts in the fire, called, by its inventor Glauber, *Sal mirabile*; whilſt a Salt compoſed of the ſame acid and vegetable alcalies is extremely difficult of-ſolution, and does not melt at all. It muſt be obſerved however, that when the common alcalies have been ſaturated with Spirit of Salt, and this compound treated with oil of Vitriol; the neutral Salt hence reſulting, after the expulſion of the marine acid, will greatly reſemble the *Sal mirabile*.

Tranſpoſitions of the acid.

The marine acid is ſeparated and transferred into other bodies, in ſundry operations, where ſuch an effect is generally little thought of. Thus in the making of corroſive Sublimate, it is the acid of the Sea-ſalt that unites with the Mercury: and in the making of butter of Antimony, it is this acid which forſaking the Mercury corrodes the antimonial Regulus into a butyraceous form.

II. SAL AMMONIAC.

SAL AM.

Its name.

SAL AMMONIAC is a neutral Salt compoſed of the marine acid and volatile Alcali: combinations of other acids with volatile Alcalies are called alſo from the name of this Salt ammoniacal. The name *Ammoniac* is derived by Salmaſius from one of the Cyrenaic territories, *Ammonia*; by others from the temple of Jupiter Ammon in Africa; by others from the Greek ἄμμος ſand, or ἀμμονιακὸν ſandy, the Salt being ſaid to have been found plentifully in Ammonia, and near Ammon's temple, in ſandy grounds.

Whether native.

The Sal ammoniac of the ancients is commonly ſuppoſed to have been a ſpecies of Sal gem. The true modern Sal ammoniac is never found native, at leaſt not in any tolerably pure ſtate. The ſaline matters thrown out by Volcanos, and which are commonly ſaid to be Sal ammoniac, have often little or nothing of an ammoniacal nature. They are of various colours, red, green, yellow, and others: in ſome ſorts I have found a little volatile Alcali, but the greater number contained none: ſome participated of the vitriolic acid, and ſome of the marine; ſome held an actual Sulphur, and ſome had a cupreous or ferrugineous impregnation.

Prepared in Egypt.

Common Sal ammoniac is an artificial preparation, hitherto made only in Egypt. The principal manufacture is at two villages lying near together, about a mile from the city Menſoura in the province of Delta, called Damire or Dameyer. In theſe there are twenty-five large and ſeveral ſmaller works; and fifteen hundred or two thouſand quintals or hundredweights of Sal ammoniac are prepared every year. There are three other works in Egypt, leſs conſiderable than the foregoing, two in the ſame province, and one at Cairo; in which laſt, the annual produce of Salt does not exceed twenty or thirty hundred weight. It is ſurprizing that means have not been found of preparing this commodity to advantage in Europe, as its conſtituent parts are perfectly known.

Enquiry into its preparation.

The ingredients from which Sal ammoniac is produced have long been mentioned in books. Cæſalpinus, if I miſtake not, was the firſt who informed us, that this Salt is obtained from ſoot, urine, and common Salt; and from theſe, it is ſtill affirmed that the Egyptian Sal ammoniac is made: the proportions commonly ſet down are, ten parts of urine, two of common Salt, and one of wood ſoot. There

Sal Am. is, however, in regard to theſe ingredients, a grand miſunderſtanding, which, ſo far as I can learn, was diſcovered by Paul Lucas, (who travelled through Egypt and other parts of Africa) and afterwards confirmed in the year 1719, by the French conſul at Cairo, by father Sicard, and more lately by one Granger. The Egyptian ſoot is not the ſame with ours: it is the ſoot of animal dung, chiefly of that of cows; which is the common fuel of that country, either dried by itſelf or mixed with ſtraw. The urine employed in the making of Sal ammoniac, is that of horſes, aſſes, or camels; and as the ſoot abounds much more than ours with a volatile animal Salt, the urine alſo is richer in ſaline matter than that of the ſame animals in theſe colder climates.

Of the manner in which Sal ammoniac is made from the foregoing ingredients, we have not as yet ſo full an account as could be wiſhed. Two of the French chemiſts, the younger Geoffroy and the younger Lemery, diſputed for ſeveral years whether it was prepared by ſublimation or inſpiſſation: Geoffroy maintained the former, and Lemery the latter. Geoffroy gave one memoir on the ſubject in 1705, and another confirming his opinion in 1716; but the academy, either imagining that Lemery was in the right, or that both opinions were equally well founded, ſuppreſſed Geoffroy's memoir, till an account ſent by the conſul at Cairo convinced them that the Salt was made by ſublimation. This gentleman obſerves, that the ſubliming veſſels are made of earth or glaſs, of a globular figure, generally a foot and a half in diameter, with a neck about two fingers high, like the common receivers; that forty or fifty pounds of the matter are put into one veſſel; that in every large elaboratory there are eight furnaces, and in every furnace ſixteen ſubliming veſſels; that the veſſel is left open for a time, till the phlegmatic parts have exhaled, and afterwards covered; and that the proceſs takes up three days and nights. This is all we know as yet of the manufacture of Sal ammoniac;

ammoniac: Granger has made ſome additional obſervations, but they contribute nothing to the principal point.

With regard to the ingredients, I am fully perſuaded, that urine, ſoot, and common Salt are not all. The common Salt would not part with its acid, and conſequently could be of no manner of uſe without the addition of Loam, Bole, or ſome of the other ſubſtances employed for the diſtillation of Spirit of Salt; and ſome ſuch addition is doubtleſs employed by the Egyptians, though it has eſcaped the notice of the gentlemen above-mentioned.——If the preparation of Sal ammoniac is attempted in this country, we are not to be confined to urine and the ſoot of dung. This Salt conſiſts of marine acid and volatile Alcali: the acid may be obtained by proper intermedia from all the ſorts of common Salt, and all animal matters furniſh a volatile Alcali. Different animal ſubſtances yield different quantities of Alcali; and ſuch are to be made choice of for this uſe as yield the moſt, and are to be procured at the leaſt expence, as dung, urine, refuſe cuttings of leather, horn, bone, hoofs, hair, wool, *&c.*

With regard to the proceſs, I apprehend that both Geoffroy and Lemery are partly in the right, but neither of them entirely ſo. The production of the volatile Alcali, and its combination with the marine acid, are doubtleſs effected by ſublimation; but the form of the cakes in which Sal ammoniac is brought to us, appears to be procured by inſpiſſation. If we ſublime Sal ammoniac in the ſame kind of veſſels in which it is ſaid to be ſublimed at firſt, it will by no means concrete into cakes, nor does any Salt we know of aſſume ſuch a form by that proceſs: on the other hand, by ſoftening the powdered Salt with water into the conſiſtence of pap, and pouring it into ſuch a glaſs as is uſed for deliquiations, (having a ſmall aperture in the bottom for ſuffering the liquid part to drain off) I have obtained a cake exactly reſembling the Egyptian. The hemiſpherical ſide of the cake, and the prominence in the middle, which Geoffroy ſuppoſes to correſpond to the upper part of the ſubliming veſſel, were here formed by the bottom of the inſpiſſating veſſel. In the middle of the cakes of Sal ammoniac we find ſome manifeſt cryſtals; and the reſt of the maſs is throughout of ſuch an uniform and continued ſtructure, as could not have been produced by conſtant caſual appoſitions of freſh matter. The inſpiſſation appears to have been performed by the Egyptians in glaſs veſſels, as we frequently find pieces of glaſs adhering to the cakes.

Cakes and loaves.

Two kinds of Sal ammoniac are diſtinguiſhed in trade, one in broad cakes, convex on one ſide and flat on the other, about two inches and a half or three inches thick; the other in large conical loaves, reſembling ſugar loaves, and probably formed in the ſame kind of moulds. This laſt ſort is ſaid by ſome to be the produce of the Eaſt-Indies: it is very rarely met with among us; the firſt ſort, which is the moſt pure, being the only one in common uſe. The cakes are uſually blackiſh on the outſide, but internally white, ſemitranſparent, eſpecially about the edges, hard, compact, and in ſome degree ſonorous, of a ſharp taſte, without any ſmell.

General properties.

Sal ammoniac diſſolves in four times its weight of water, and renders the liquor ſenſibly colder: the greateſt degree of cold hitherto produced in water by artificial mixture, without ice, reſults from a compoſition of Sal ammoniac, Mercury-ſublimate, and Vinegar. Several experiments of this kind, and of vegetations or curiouſly figured cryſtallizations of Sal ammoniac, may be ſeen in the French Memoirs. It is ſaid, that a ſolution of Sal ammoniac wrote with on paper, on which it leaves no ſtain, will become viſible on expoſing the paper to the fire; and that paper or linen moiſtened with this ſolution will not burn. On trial, the writing did not become legible when heated (*p*), and the paper impregnated with the Salt burnt and conſumed, though it did not flame.

Sublimation.

Sal ammoniac proves totally volatile in a heat conſiderably below ignition, nearly in ſuch a degree of heat as Lead requires for its fuſion. If no other ſubſtance is added that may diſunite its conſtituent parts, it ſublimes unchanged. By repeated ſublimations, however, it acquires at length a yellowiſh tinge, and a particular ſmell, of which it diſcovered nothing at firſt. Theſe alterations proceed from the oily or inflammable matter of the volatile animal Salt; for that Sal ammoniac participates of that principle, appears from its deflagration with Nitre. The detonation is moſt obſervable when four parts of Nitre are mixed with one of the Sal ammoniac; a mixture of three parts with one deflagrate but weakly, and two with one, not at all.

Deflagrates with Nitre.

Volatilizes metals.

This Salt remarkably opens and volatilizes metallic bodies, eſpecially if they have been previouſly reduced into calces or precipitates; even the moſt fixed of all known ſubſtances, Gold, may be forced over the helm by means of Sal ammoniac: Regulus of Antimony is ſo attenuated by it, as to diſſolve in Vinegar, if not in water. By repeated ſublimations, both the Salt itſelf, and combinations of it with other bodies, become leſs and leſs volatile. Pure Sal ammoniac, after a number of ſublimations, proves at length ſo fixed as to remain half fluid in the bottom of the ſubliming veſſel. On ſubliming Mercury-ſublimate with Sal ammoniac, mixing the matter which aroſe with the reſiduum, and repeating the operation ſeveral times, the matter at laſt became quite fixed in the fire, and would no longer riſe from the bottom of the glaſs. On ſubliming together a mixture of Sal ammoniac, Mercury, and Sulphur, there remains every time a little fixed browniſh-red matter, which bears a conſiderable

Made fixed

(*p*) *Characters drawn with ſolution of Sal ammoniac not legible when heated.*] They do not become viſible by being moderately heated; but if the heat is ſuch as to ſlightly ſcorch the paper, the part impregnated with the ſaline ſolution will be burnt black, whilſt the reſt is ſcarcely brown.

SAL AM. derable melting heat, and is called by ſome fixed Cinnabar.

Uſes. Sal ammoniac is made uſe of in ſundry mechanic buſineſſes, by the dyers, glaſs-makers, but more particularly by thoſe who work upon metals, for ſoldering, *&c.* Gold is taken off from gilt Silver, by heating the veſſel red-hot, and quenching it in a ſolution of a pound of Borax, a pound of Tartar, and an ounce and two drachms of Sal ammoniac.——As a medicine, it is accounted powerfully antiſeptic, aperient, diuretic, and diaphoretic. A doſe of half a drachm, or a drachm, is recommended in quartan agues; and ſaid, if it fails the firſt time, to cure with certainty on repeating it: experience has ſhewn, that it is a medicine of remarkable efficacy in agues, though it does not in all caſes ſucceed. Given too frequently, or in too large doſes, it is ſaid to injure the ſtomach and chill the habit. Externally it is employed againſt films on the eyes of cattle, in gargariſms for quinſeys, in applications for gangrenes, for reſolving ſwellings and nodes in the breaſts, when not of long ſtanding or accompanied with inflammation, and for other like purpoſes. An ointment againſt nodes and ſoft excreſcences is compoſed of ſix ounces of Sal ammoniac, three drachms of Ceruſſe, one drachm of Camphor, and a proper quantity of Oil of Roſes.

Purification. The moſt ſimple preparation of Sal ammoniac is its purification. This is effected either by ſolution in water, filtration, and cryſtallization, or by ſublimation. The firſt method is greatly to be preferred; for ſublimation ſeparates only the ſand, bits of glaſs, or other like groſs ſubſtances that have been caſually mingled with the Salt, the ſooty and oily impurities ſubliming along with it. By ſublimation alſo the inflammable principle of the Sal ammoniac more and more diſcovers itſelf, and communicates both a colour and ſmell to the Salt. By ſolution and cryſtallization it is effectually purified from all the ſubſtances commonly mixed with it, that are not eſſential to its compoſition. Some ſublime the Sal ammoniac from common Salt: this addition ſomewhat varies its quality, eſpecially if the ſublimation is ſeveral times repeated, a portion of the volatile acid of the common Salt being imbibed by the Sal ammoniac. SAL AM.

Martial flowers. The *martial flowers* of Sal ammoniac are prepared commonly from one part of Iron filings or *Lapis hæmatites* and two of the Salt, mixed well together, ſet by for ſome days in a cellar, ſtirred two or three times a day, then put into a low glaſs body fitted with a head, and expoſed to a gentle heat till the matter becomes thoroughly dry; after which, the fire is increaſed till nothing more will ſublime. After the water has ariſen, a volatile ſpirit comes over, and after this a little acid ſpirit. The flowers which ſucceed are of an orange yellow, a reddiſh and pale yellow colour, and are found to be no other than the Sal ammoniac in its whole ſubſtance, tinged by the Iron which it has volatilized. The reſiduum deliquiates in the air, and appears to be no other than a ſolution of Iron in the marine acid. It is cuſtomary to grind the flowers with the reſiduum, and ſublime them afreſh, to repeat this operation ſeveral times, the flowers becoming by this means of a deeper and deeper red colour. I once tried how much Sal ammoniac a certain quantity of *Hæmatites* was capable of tinging: at firſt I took two pounds of each, and to the reſiduum of this proceſs added one pound of freſh Sal ammoniac, repeating the ſublimation with a pound of Sal ammoniac every time for twelve times ſucceſſively. All the fourteen pounds of Sal ammoniac were thus tinged by the two pounds of blood-ſtone: till the eleventh ſublimation, the flowers ſeemed to be deeper and deeper coloured, but thoſe of the following ſublimations were paler: on mixing with the laſt reſiduum another pound of Sal ammoniac, the ſublimate had little colour; and on trying a pound more it aroſe grey. Some, inſtead of filings of Iron or Blood-ſtone, uſed Crocus of Iron, or *Caput mortuum* of Vitriol: the flowers in either caſe are the ſame.

Deliqueſcence of Sal ammoniac and Vitriol.

It is obſervable, that green Vitriol and Sal ammoniac ground together grow as ſoft as pap, and in part liquefy, eſpecially if the quantity of Vitriol is double or equal to that of the Sal ammoniac. There ſeems to happen here a tranſpoſition of the conſtituent parts of the ingredients: the acid of the Vitriol is transferred into the volatile Alcali of the Sal ammoniac; and the acid of the Sal ammoniac into the Iron of the Vitriol: hence the taſte of the compound is extremely ſtyptic, like that of the common ſolutions of Iron in the marine acid.

Flowers of Copper; of Regulus of Antimony.

Venereal and antimonial flowers of Sal ammoniac have likewiſe been prepared for medicinal uſe, the firſt by ſubliming the Salt with *Caput mortuum* of blue Vitriol, the latter with Regulus of Antimony. The antimonial flowers are one of the more violent preparations of that mineral; and the venereal ones, like the other preparations of Copper, are entirely unſafe. The ſimple Regulus of Antimony yields white flowers; the martial Regulus fine red ones, eſpecially if the ſublimation be ſeveral times repeated till little or nothing is left.

Aqua regia.

Sal ammoniac diſſolved in four times its quantity of Spirit of Nitre, makes the common Aqua regis: the Salt ſhould be previouſly pulveriſed in a glaſs or ſtone mortar; and a gentle warmth applied to promote its ſolution in the ſpirit. If a ſpherical glaſs veſſel be nearly filled with good Spirit of Nitre, a quantity of Sal ammoniac, more than it can diſſolve, thrown in, and the whole ſuffered to remain quiet, a curious vegetation ariſes, which Kunckel was the firſt I know of that obſerved. Sal ammoniac, Quick-lime, and water, kept for a night in a Copper or braſs veſſel, or along with pieces of Copper, diſſolve a part of the metal, with which the liquor is tinged blue: this is the *Aqua cærulea* or *Sapphirina* of the ſhops. The Copper is here diſſolved by the volatile Alcali of the Sal ammoniac extricated by the Quick-lime.

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Volatile Salt; general principle of its ſeparation.

The volatile alcaline Salt, and the ſpirit, or ſolution of the volatile Salt, are the principal preparations of Sal ammoniac kept in the ſhops. The volatile Alcali is never to be ſeparated without the intervention of ſome other body with which the acid has a greater affinity, as fixed alcaline Salts or abſorbent earths. One part of powdered Sal ammoniac is commonly mixed with two or three of Salt of Tartar or purified Potaſh, the mixture moiſtened with a little Spirit of Wine, put into a retort, to which a receiver is adapted, and the fire increaſed by degrees: in England whiting is uſed for the intermedium, and aludels are ſometimes applied to the retort. By either of theſe methods, the volatile Salt ſublimes in a concrete form, the marine acid of the Sal ammoniac remaining united with the fixt Salt, or the whiting, at the bottom of the retort.

quantity.

Tournefort obtained ten ounces of volatile alcaline Salt from fifteen of Sal ammoniac. Hoffman affirms that ſixteen ounces of Sal ammoniac contain twelve of Alcali and four of Acid. Geoffroy obtained no leſs than thirteen ounces from ſixteen, beſides a conſiderable quantity of ſpirit, that is of Salt diſſolved; inſomuch that he concludes fifteen ounces in the pound to be pure volatile alcaline Salt, and only one ounce acid. (See the French Memoirs for the year 1723.) He appeals to two other experiments for the truth of this aſſertion. The firſt is, the production of a Sal ammoniac perfectly neutralized, from fifteen ounces of volatile alcaline Salt and a quantity of Spirit of Salt that ſhall be found to contain an ounce of pure acid: the ſecond experiment is, that if a mixture of three parts of dry Salt of Tartar and one part of dry Sal ammoniac be ſtrongly calcined in a crucible, that all the volatile Alcali may be expelled, the acid retained by the Salt of Tartar will increaſe its weight only one ſixteenth of the weight of the Sal ammoniac employed. It ſeemed to me improbable, that a ſingle ounce of acid ſhould fully ſaturate fifteen ounces of volatile Alcali; and therefore

Salt of Tartar volatilized.

fore I repeated both the ſublimation and the counterproofs he appeals to. One pound of Sal ammoniac and three of Salt of Tartar, thoroughly dried, and reduced into a fine powder, were well mixed together, put into a retort, the junctures cloſely luted, and, after ſtanding for a night, ſublimed: the volatile concrete Salt amounted to no leſs than thirteen ounces: there was alſo ſome ſpirit, but not ſo much as that two ounces more of Salt could be reckoned for it; and the quantity of reſiduum was a good deal greater than Geoffroy's. I repeated the experiment with pure dry Salt of Tartar prepared on purpoſe, and with purified Potaſh: with this laſt, the quantity of volatile Salt was an ounce leſs than with the other. With regard to the other experiments, an ounce of pure and pretty ſtrong ſpirit of Salt required for its ſaturation two drachms of volatile Alcali; and fixt Alcalies calcined with Sal ammoniac, inſtead of gaining, loſt notably of their weight. Three drachms of Salt of Tartar, after gentle calcination with one drachm of Sal ammoniac, weighed but two drachms thirty-four grains: the ſame quantities calcined by a ſtronger fire, left but one drachm and two ſcruples. I likewiſe calcined ſome Salt of Tartar by itſelf, and found it to loſe ten grains upon a drachm: calcined with twice its weight of Sal ammoniac it loſt exactly the ſame. Half a drachm of the calcined Salt being mixed with half a ſcruple of Sal ammoniac, there remained after calcination no more than twenty-five grains. From theſe experiments it appears, that a part of the Salt of Tartar is volatilized by the Sal ammoniac (q), and that the Sal ammoniac does not contain ſo much volatile Salt as is produced in its analyſis. Probably Geoffroy's obtaining more volatile Salt proceeded from ſome differences in the fixed Salts made uſe of: the French Potaſh, and Quicklime, are found in ſome experiments to differ from ours: proceſſes with Quick-lime, which I have performed numbers of times at London without once failing, I could never once make ſucceed at Paris.

(q) *Salt of Tartar volatilized by Sal ammoniac.*] Mr. du Hamel has fully proved that a conſiderable portion both of fixed alcaline Salts and of Chalk, is elevated in ſublimation along with the volatile Salt of Sal ammoniac: by both intermedia he obtained more, ſometimes one half more volatile Salt, than the quantity of crude Sal ammoniac made uſe of: even the volatile Salt itſelf, by bare ſublimation from fixed Alcalies, in a moderate heat, gained an augmentation of its weight. The volatile Salts, thus loaded with Salt of Tartar or Chalk, did not part with their fixed matter on being diſſolved in water, and repeatedly ſublimed

Spirit of Sal ammoniac.

Spirit of Sal ammoniac is no other than the volatile Salt diſſolved in phlegm or water. The moſt commodious method of preparing it is, to diſſolve the Sal ammoniac in as little water as it will diſſolve in, and to pour into this ſolution, in a retort, a ſolution of an equal quantity or more of Salt of Tartar or Potaſh, then immediately to lute on a receiver, and proceed to diſtillation with a gentle fire: the volatile ſalt will ariſe before the water, and concrete about the ſides of the receiver: when water enough has come over to diſſolve the Salt, the proceſs ſhould be diſcontinued. The ſpirit will now be fully ſaturated with Salt; whereas if the diſtillation is protracted beyond this period, the ſpirit will be proportionably weakened or diluted.

Calcareous earths, as Chalk or Whiting, extricate the volatile Alcali of Sal ammoniac as effectually as fixt Alcalies; but they do not produce their effect till they have ſuffered ſome degree of calcination. If Sal ammoniac and fixt Alcali be barely mixed together either in a ſolid or a liquid form, a ſtrong pungent odour will inſtantly diſcover that the volatile Alcali is ſet at liberty; but on mixing the Sal ammoniac with Chalk no ſmell is perceived till the matter has been conſiderably heated, and then the volatile Salt ſublimes in its proper form,

Spirit with Quicklime.

When the earth is previouſly calcined into Quicklime, the phænomena are very different. Quicklime

limed or diſtilled with very gentle degrees of heat: they totally ſublimed alſo when neutralized by acids into ammoniacal Salts: a ſolution of them in water, expoſed for ſix weeks to the air, and then exhaled, left nothing behind. But on expoſing one of them dry to the air, there remained a fixed ſubſtance, which proved to be Chalk.

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lime mixed with Sal ammoniac, raiſes immediately a more volatile and penetrating ſmell than that occaſioned by fixed Alcalies: from this mixture no concrete Salt is obtainable, the whole of the Salt being converted into a permanently fluid ſpirit, and its ſubtility and volatility remarkably increaſed. — The Spirit of Sal ammoniac with Quick-lime may be prepared from one part of the Salt, and three of the Lime broke in pieces about the ſize of hazel nuts. The Sal ammoniac is to be diſſolved in water, and put into a retort, the Quick-lime thrown in, and a receiver immediately luted on: a ſmall quantity of a very ſubtile ſpirit will ariſe during the ſlaking of the Lime: when the heat proceeding from this cauſe ceaſes, a gentle fire is to be applied, and continued till nothing more will come over. If a ſtronger ſpirit is wanted, ſlaked Lime; and if a ſtill ſtronger, freſh Quick-lime may be uſed, without any water. From eight ounces of Sal ammoniac and ſixteen of Lime ſlaked in the air, I have obtained ſix ounces and ſix drachms, ſometimes more though oftener leſs: from the ſame quantities of Sal ammoniac and freſh Quick-lime I gained only one ounce and ſix drachms; but this laſt ſpirit was far more volatile than the other, and ſo ſtrong as to ſtrike one down upon incautiouſly taking off the receiver: the ſpirit with ſlaked Lime, though far ſtronger than the common Spirit of Sal ammoniac, was mild in compariſon to this.

Efferveſcence of the volatile ſpirits with acids.

The Spirit of Sal ammoniac made with fixed alcaline Salts, efferveſces ſtrongly with all acids; the ſpirit made with Quick-lime very weakly. Hoffman affirms, that the ſpirit prepared with Quick-lime raiſes no efferveſcence with any acid, miſled by confounding the aqueous or pure ſpirit with the vinous. Both the aqueous and vinous ſpirits made with fixed alcaline Salts efferveſce ſtrongly: the vinous with Quick-lime, not at all; the aqueous with Quick-lime very ſenſibly, though not near ſo much when newly diſtilled as after it has been long kept: on keeping for ten years it loſt almoſt all its volatility and ſubtility, and in this ſtate it effervesced ſtrongly. — Homberg reports that Spirit of Sal ammoniac raiſes no effervescence with any vegetable acid; but the ſpirit with fixed Alcalies manifeſtly does, if added in due proportion, and even that with Quick-lime produces a ſparkling. The common vegetable acids are ſo dilute, that when they are added to alcaline liquors, a large quantity of the acid muſt be poured in to raiſe any ſenſible commotion: to a drachm of good Spirit of Sal ammoniac I have often added a pound, a pound and a half, and even two pounds of weak diſtilled Vinegar, before the effervescence begun. On the other hand, if we drop the volatile ſpirit into ſtrong diſtilled Vinegar an effervescence will ſoon appear.

Divers experiments with Quick-lime.

The ſingular effects of Quick-lime in the diſtillation of Sal ammoniac have been accounted for by many, but on principles groundleſs or abſurd: their true cauſe may, perhaps, be that the Quick-lime abſorbs and detains the earthy matter which is the baſis of the volatile Salt, and on which its ſolid form and its effervescence with acids depend. I have tried the effect of Quick-lime in compoſition with fixed Alcalies, and found that four drachms of Sal ammoniac and eight of Salt of Tartar, with one drachm of Quick-lime moiſtened with a little water, yielded both a concrete Salt and a Spirit; that with two drachms of Quick-lime a dry Salt was ſtill obtained; but that upon increaſing the Quick-lime to three drachms and a half, only a fluid volatile ſpirit aroſe. I have likewiſe treated with Quick-lime the Salt and Spirit prepared by fixed Alcalies: a little Quick-lime added to the Spirit, diminiſhes its volatility more and more in proportion to the quantity of Lime: twelve ounces of a ſaturated Spirit being drawn over twenty times from freſh parcels of Quick-lime, three ounces each time, the volatility of the ſpirit was in good meaſure deſtroyed, and by a few more repetitions it was totally ſo: the concrete volatile Salt I have totally deſtroyed by bare Lime-water. (See page 24.)

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Cauſtic volatile Spirit by metallic ſubſtances.

The volatile Alcali of Sal ammoniac is extricated alſo in a fluid ſtate by ſome metallic ſubſtances. One part of Sal ammoniac ground with three of Minium, and diſtilled in a retort, yields a ſmall quantity of alcaline Spirit, the moſt penetrating and cauſtic of any volatile Alcalies I know of: a ſingle drop laid on the tongue, quickly makes a hole as large as half a pea. The reſiduum of this proceſs has oftentimes an elegant Marble-like appearance. Some diſputes with the elder Geoffroy, who in his defence of his table of affinity, attributed the extricating of the Alcali of the Sal ammoniac to a fixed alcaline or calcareous matter produced in the Minium during its preparation, induced me to examine ſome other metallic bodies in their metallic ſtate, where no ſuch cauſe can be ſuppoſed to exiſt: filings of Lead, Zinc, Regulus of Antimony, Iron, were all found to extricate a little volatile ſpirit.

Volatile with vinous ſpirits.

Spirit of Sal ammoniac made with fixed Alcalies, forms on the admixture of rectified Spirit of Wine, a white coagulum, called *Offa alba*, the volatile Salt not being ſoluble in the vinous ſpirit, and being diſlodged by it from the water which held it in ſolution before. The ſpirit made with Quick-lime, on the other hand, whoſe ſaline matter is ſo attenuated as not to aſſume a ſolid form, unites equably with the moſt highly rectified Spirit of Wine, without coagulation or precipitation. Hence this laſt ſpirit is much better adapted than the other for mixtures with vinous ſpirits. — The vinous or dulcified Spirit of Sal ammoniac of the ſhops is prepared with fixed alcaline Salts, and conſequently holds but little of the volatile Alcali: ſome mix the aqueous alcaline Spirit with Spirit of Wine, and others uſe a vinous ſpirit inſtead of water, in the firſt diſtillation.

It may ſeem a paradox, that volatile Alcalies ſhould precipitate a fixed Alcali, and that they ſhould precipitate it from a liquor with which they ſeem to have themſelves ſo little affinity as Spirit of Wine. Such however is the caſe: Stahl's *Mixtura Tonico-*

nervina conſiſts of the *Tinctura Tartari* or *Tinctura Antimonii* and volatile ſpirit; when a large quantity of the fixed alcaline tincture is added to a ſmall one of the volatile ſpirit, an *Oleum Tartari per deliquium* ſeparates to the bottom.

Volatile oily ſpirits.

Sundry compound or oily Spirits of Sal ammoniac are kept in the ſhops for medicinal uſes. There are various compoſitions of theſe kinds of liquors, and various methods of preparing them. Different aromatic and other ſubſtances, as Aniſeeds, Fennel-ſeeds, Lavender, Juniper-berries, Cloves, Saſſafras, Amber, *&c.* or the oils diſtilled from them, ſingly or combined with one another, are digeſted in the vinous Spirit of Sal ammoniac, or diſtilled along with it, or added in its firſt diſtillation from Sal ammoniac and fixt alcaline Salt. The diſtillation of theſe kinds of compoſitions is entirely unneceſſary, nor is it at all needful to keep them ready prepared in the ſhops, as they may be eaſily made extemporaneouſly with different oils, or different proportions of oil, as the phyſician may think fit. It is ſufficient if we have at hand a good dulcified Spirit of Sal ammoniac that will readily diſſolve oils.

Uſes of volatile Alcalies.

The Salt and Spirit of Sal ammoniac are the pureſt of the volatile Alcalies, and hence generally made choice of for chemical operations, as the precipitation of Aurum fulminans, of Mercury, *&c.* It is obſervable, that theſe ſpirits precipitate Mercury from Aqua fortis of a blackiſh-grey colour, but from ſolution of corroſive Sublimate white, and that they give a blackiſh colour to *Mercurius dulcis.* Medicinally, they are exhibited as ſtimulants, aperients, *&c.* in paralytic, hyſteric, and ſundry other diſorders: in plethoric habits they ſhould be given with caution, as they are apt in theſe caſes to bring on dangerous hæmorrhages. The volatile Salt was formerly given by a drachm at a time, but the preſent practice has juſtly reduced the doſe within ſmaller limits. Boerhaave obſerves that this Salt is ſo corroſive, that when laid upon the moiſt ſkin, and covered with a ſticking

SAL AM. plaſter to prevent its flying off, it preſently occaſions a violent inflammation and gangrene. The Salt either by itſelf, or impregnated with odoriferous oils, is uſed in ſmelling bottles by the name of Engliſh Salts. The ſpirit made with Quick-lime is ſeldom given internally on account of its great pungency, but frequently uſed for ſmelling to, and in ſome external applications: agitated with oils, it readily unites with them into the conſiſtence of a liniment.

Reſidua after the diſtillations. What remains in the retort after the diſtillation of the volatile Salt and Spirit of Sal ammoniac, is the marine acid of that concrete combined with the intermedium. When fixed alcaline Salts have been uſed, the reſiduum diſſolved in water and cryſtallized, proves no other than a regenerated Sea-ſalt, though dignified with the titles of *Sal digeſtivum*, *aperitivum*, *febrifugum*, *diureticum*, *hypochondriacum*, *embryonatum*. Where Quick-lime has been employed, the reſiduum elixated with water, yields on evaporating the ſolution, a pungent ſaline maſs, called *Sal ammoniacum fixum*, ſimilar to one prepared by diſſolving Lime directly in the marine acid.

Acid ſpirit of Sal ammoniac. Hitherto we have ſeen the volatile Alcali of Sal ammoniac extricated in its proper form, by the addition of ſubſtances which abſorb the acid: we may likewiſe obtain the acid in its pure ſtate, by additions which abſorb the Alcali; for without additions of one or the other kind, no ſeparation can be made. If Oil of Vitriol be dropt upon Sal ammoniac in a tubulated retort, a highly concentrated marine acid ariſes in white clouds, which difficultly condenſe, and in part eſcape through the luting, unleſs ſome liquid is placed in the receiver to imbibe them and promote their condenſation: this ſpirit is in all reſpects the ſame with that obtained by the ſame means from common Salt: the reſiduum is the ſame with the combination of vitriolic acid and volatile Alcali called *Sal ammoniacum ſecretum*. See page 300.

Aqua pugilum. Three parts of Sal ammoniac and two of Nitre mixed together, and injected into a tubulated retort made red-hot, yield a compound acid ſpirit, participating of the marine acid of the one ingredient, and the nitrous of the other. This proves a ſubtile kind of Aqua regis: it is called by Baſil Valentine and others, *Aqua pugilum*; and *Aqua chryſulca*. In ſome places, common Aqua regis is called *Aqua chryſulca*. This laſt name gave once occaſion to a fatal miſtake: a Poliſh gentleman having aſked for Brandy by the Poliſh name *Gorſalko*, received the *Aqua chryſulca*, and was killed by it.

ARTICLE III.

Combination of the marine acid with earths.

Marine acid with different earths.

THE marine acid diſſolves all the mineral calcareous earths, and the aſhes of vegetable and animal ſubſtances, but not all with equal facility or in equal quantity. An ounce of Spirit of Salt diſſolved but forty-ſix grains of Bezoar-ſtone: of Pearl and Mother-of-pearl it took up two drachms; of ſea-ſhells, Coral, and calcined Hartſhorn, ſomewhat more; of Quick-lime, and of ſlaked Lime, ſtill more; of Crab's eyes, three drachms and upwards: theſe laſt it diſſolves not only in largeſt quantity, but moſt readily of all the earths made trial of. The ſolutions of ſome of the earths, as eggſhells, are in taſte remarkably bitter.

Fixed Sal ammoniac.

All the combinations of the marine acid with earthy bodies, when exſiccated by heat, liquefy again in the air; hence they have been often miſtaken for a fixt alcaline Salt, particularly the combination with Quick-lime, which being obtained as a ſecondary product in the diſtillation of Spirit of Sal ammoniac with that earth, has been in general more known than the others, and diſtinguiſhed by the name of *Sal ammoniacum fixum*. This Salt melts in a ſmall heat, like water, and being poured into a clean Iron mortar, appears, when cold, of a yellowiſh white colour, and ſemitranſparent

SAL AM. rent like horn. Fixed alcalies added to a diluted ſolution of it, precipitate the earth, and form with the acid a regenerated Sea-ſalt: if the ſolutions of the fixed Sal ammoniac and of the Alcali are both ſaturated, inſtead of a precipitation, the two liquors coagulate on mixture and become conſiſtent. Phoſphorus. Homberg obſerves, that fixed Sal ammoniac melted into a maſs, appears luminous in the dark on being beat in a mortar, or ſtruck upon with a hammer, and hence calls it a new Phoſphorus: the experiment does not always ſucceed.

BORAX.

BORAX. History. BORAX is a ſaline ſubſtance, of which neither the origin, or the component parts are as yet known. It comes from the Eaſt-Indies in little cryſtalline maſſes, ſomewhat reſembling ſmall cryſtals of Sal gem, mixed with earth and other impurities. Whether it is a natural or artificial production, we have no ſatisfactory account: moſt probably it is in great meaſure artificial, and the earthy matter deſignedly mixed with it, to make us look upon it as a foſſil Salt peculiar to the Indies. It is refined in Europe, but this proceſs alſo is kept a ſecret: ſome additional ſubſtances are generally ſuppoſed to be employed, the refined Borax being in larger cryſtals than we can make this Salt to ſhoot into by itſelf *(r)*. The refining of Borax was formerly practiſed

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(r) *Hiſtory of Borax.*] It is commonly ſaid, that Borax is prepared in the eaſtern countries from a green ſaline liquor, which runs from certain hills, and is received in pits lined with clay, and ſuffered to evaporate by the ſun's heat; that a bluiſh mud, which the liquor brings along with it, is frequently ſtirred up, and a bituminous matter which floats upon the ſurface taken off; that when the whole is reduced to a thick conſiſtence, ſome melted fat is mixed, the matter covered with dry vegetable ſubſtances, and a thin coat of clay: and that when the Salt has cryſtallized, it is ſeparated from the earth by a ſieve.

In the ſame countries is found in conſiderable quantities, a native mineral alcaline Salt on the ſurface of the earth, ſometimes tolerably pure, praƈtiſed only at Venice, and hence the refined Borax was called Venetian; but the Dutch are now the only maſters of this manufaƈture. Serapio calls the rough

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pure, more commonly blended with heterogeneous matters of various colours: the *Nitrum* or *Natron* of the ancients, the *Baurach* of the Arabians. This Alcali appears to be the ſame with the baſis of Sea-ſalt, and with the lixivial Salt of Kali or Kelp and ſome other maritime plants. It differs from the common vegetable Alcalies, in being milder and leſs acrid in taſte, aſſuming a cryſtalline appearance, not deliquiating in the air, or very ſlowly; forming with the marine acid a perfeƈt Sea-ſalt, with the nitrous quadrangular Nitre, and with the vitriolic a Sal mirable.

Mr. Pott received from Tranquebar, (where the greateſt quantities of Borax are made) a ſand, under the name of Ore of Borax, with an account that certain acrid vegetable matters were added in the preparation of the Borax. The ore yielded on elixation, only the mineral Alcali, with a little Sea-ſalt.

The mineral Alcali appears from experiment to be a principal ingredient in Borax. On treating Borax with acids, about one fourth its weight of a peculiar ſaline ſubſtance (called ſedative Salt) is ſeparated, and the reſiduum proves a combination of the Alcali with the acid employed: thus when the marine acid is uſed a genuine Sea-ſalt remains; when the nitrous, a quadrangular Nitre; and when the vitriolic, a Sal mirable. The ſubſtance ſeparated joined to the miniral Alcali, to the baſis of Sea-ſalt, or to the Salt of Kali, recompoſes Borax again.

The properties of this ſubſtance ſo far as they are known, are theſe. It is of a bright ſnowy whiteneſs, extremely light, compoſed of fine plates or ſcales, ſoft, and as it were unƈtuous to the touch, of no ſmell, of a bitteriſh taſte, accompanied with a ſlight impreſſion of coldneſs. It diſſolves difficultly in boiling water, and on the liquor's cooling, cryſtallizes on its ſurface, into thin plates; which uniting and becoming larger, fall to the bottom. It likewiſe diſſolves, by the aſſiſtance of heat, in reƈtified Spirit of Wine: the ſolution ſet on fire burns with a green flame. Moiſtened and expoſed to a conſiderable heat, it in part ſublimes; by repeated humeƈtations the whole may be elevated. Whilſt dry, it proves perfeƈtly fixed: it melts, emits aqueous vapours, and runs into a vitreous ſubſtance, diſſoluble again as at firſt: neither the glaſs nor the Salt itſelf are affeƈted by the air. It makes no change in the colour of blue flowers. It unites with the common alcaline Salts, in ſome degree neutrallizes, and renders them capable of cryſtallization. It is ſaid to expel from Alcalies every acid except the vitriolic, though expelled itſelf by every acid from the alcaline baſis of the Borax.

Thus we find Borax compoſed of two principles, one every where plentiful, another which has not hitherto been obtained but from Borax itſelf; the laſt in the ſmalleſt proportion. How far this peculiar ſubſtance is natural or artificial, of mineral or of vegetable origin, is wholly unknown.

With regard to the refining of Borax, the rough Salt is ſaid by ſome to be diſſolved in Lime-water, by others in alcaline Lixivia, by others in a Lixivium of cauſtic Alcali, and by others in Alum-water.

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Borax as it comes from the Indies, *Tincar*; and the dealers in this commodity ſtill diſtinguiſh it by the name *Tincar* or *Tincal*, never calling it Borax till it is refined. *Baurach* among the Arabians, and *Chryſocolla* among the Greeks, were names for this Salt, but they were applied alſo to other ſubſtances; the firſt to the *Natrum* or Nitre of the ancients: the latter to a green cupreous mineral now called *Berggrun* or *Viride montanum.*

Proceſſes for artificial Borax falſe.

There are great numbers of proceſſes in books for making Borax by art: I have tried thoſe which ſeemed to be the beſt, and made ſundry other experiments on principles of my own, without being ever able to ſucceed. That this Salt is nevertheleſs artificially producible, I make no queſtion: Stahl obtained cryſtals approaching to Borax from certain antimonial ſcoriæ expoſed for a length of time to the air. See his ſupplement to Becher's *Phyſica Subterranea.*

General properties.

Refined Borax is a ſolid, colourleſs, tranſparent, cryſtalline Salt, apparently of the neutral kind, but inclining to an alcaline nature. It makes no efferveſcence with alcalies or acids. It has ſomewhat of an alcaline taſte, changes Syrup of Violets greeniſh, extricates a little volatile Alcali from Sal ammoniac, throws down an orange-yellow Precipitate from ſolution of Sublimate corroſive, and precipitates ſundry metallic and earthy ſolutions made in acids, as ſolutions of green, blue, and white Vitriol, of Mercury in Aqua fortis, of Silver in Aqua fortis: of Copper in Spirit of Salt, of Lead in Vinegar, of Copper in Vinegar, of Zinc, of Biſmuth, of Iron in Aqua regis and

Precipitates ſundry acid and alcaline ſolutions.

Thus much is certain, that Borax diſſolved in common water, and cryſtallized in the common manner, forms extremely ſmall cryſtals: that theſe differ in ſeveral reſpects from the refined Borax of the ſhops, inſomuch that Cramer calls the latter not a purified but adulterated Borax; that Borax ſhoots into larger cryſtals when diſſolved in Lime-water than in common water; and when the veſſel is covered, and a gentle warmth continued during the cryſtallization, than in other circumſtances . . . It is obſervable that Borax, during its diſſolution, appears tenacious, and adheres in part to the bottom of the veſſel: from this glutinous quality, peculiar to Borax among the Salts, it is employed by the dyers for giving a gloſs to ſilks.

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and in Spirit of Nitre, of Alum, and of fixed Sal ammoniac. It precipitates alſo ſome ſolutions made in Alcalies, as Sulphur diſſolved in alcaline Lixivia, and Reſin diſſolved in a ſolution of fixed Nitre. It precipitates Sulphur from Lime-water: on mixing a ſolution of Borax with Lime-water itſelf, a turbidneſs and precipitation enſue: Spirit of Sal ammoniac made with Quick-lime produces a like effect after the mixture has ſtood for ſome days (*s*).

Examined by water.

This Salt requires thirty times its own weight or more of water to diſſolve in. The cryſtals expoſed to the ſun, loſe a part of the humidity of which they contain a large quantity in their cryſtalline form, and fall by degrees in a white powder. In the fire they readily melt and boil up, and parting with their water, turn to a light, white, ſpongy maſs, which, on raiſing the heat, melts into a ſubſtance like Glaſs (*t*).

In the fire.

(*s*) *Borax with acids*, &c.] All acids diſſolve Borax ſlowly and without effervescence. It precipitates from them moſt, but not all metallic ſubſtances; along with which a conſiderable part of the Borax is generally depoſited. It does not abſorb the marine acid of *Luna cornea* or of Mercury-ſublimate: it flows upon the ſurface of the firſt without uniting, and ſuffers the latter to ariſe unchanged: the Borax in both caſes becomes coloured, in the firſt milky with red ſtreaks, in the latter amethyſt or purple. Mixed with Sal ammoniac, it extricates the volatile Alcali, and retains the acid; but mixed with a combination of the ſame acid with calcareous earths, called fixed Sal ammoniac, it extricates the acid, and unites with the earth. It extricates the acid of Nitre, without ſeeming to unite with the alcaline baſis of that Salt. Nor does it mingle in fuſion with the common fixed alcaline Salts, the Borax flowing diſtinct upon the ſurface.——A mixture of Borax with twice its weight of Tartar, diſſolves in one ſixth the quantity of water that would be neceſſary to diſſolve them ſeparately: the liquor yields, on inſpiſſation, a viſcous tenacious maſs like glue, which refuſes to cryſtallize, and which deliquiates in the air. Borax affords likewiſe a glutinous compound with other acids, except the vitriolic: it proves moſt glutinous with the vegetable, and leaſt with the marine.——With oils both expreſſed and diſtilled, it forms a milky ſemiſaponaceous compound. It partially diſſolves in Spirit of Wine. In conjunction with any acid, it tinges the flame of burning matters green: the Precipitate thrown down by it from metallic ſolutions has this effect.—It does not deflagrate with Nitre. Fuſed with inflammable matters, it yields nothing ſulphureous as thoſe Salts do which contain vitriolic acid.

(*t*) *Glaſs of Borax.*] Borax is the only Salt that aſſumes a vitreous appearance from fire without addition. The Glaſs ſo called, becomes opake, and at length powdery in the air, like the Borax at firſt, the Salt ſeeming to have ſuffered from this proceſs no other real alteration than the

BORAX. Lemery relates, that this Glaſs will ſtill diſſolve in water, and cryſtallize into Borax again. If the fuſion is performed in a retort with its receiver, we obtain from a pound of Borax near ſeven ounces of phlegm; the vitrified reſiduum weighs a little more than nine ounces. The phlegm has ſomewhat of a ſoapy ſmell: if Salt of Tartar be added in the diſtillation, the diſtilled liquor proves manifeſtly unctuous or oily. Lemery obtained from an ounce and a half of Borax, and twice as much dry Clay, three drachms of an urinous liquor.

Uſes. Borax is uſed chiefly in ſoldering, for promoting the fuſion of calces of Gold and Silver, and reuniting the particles of thoſe metals into one maſs when diffuſed through a quantity of earthy matter, for facilitating the vitrification of calces of Antimony, *&c.* It weakens the colour of Gold, and, by repeated fuſions, renders it quite pale (*u*). It is ſometimes employed medicinally in compoſitions for promoting delivery as an emmenagogue in aphrodiſiac, coſmetic, dentifrice, *&c.*

Sedative Salt. The principal preparation of Borax is a volatile ſaline concrete, called *Flores boracis*, *Sal volatile vitrioli*, *Flores vitrioli philoſophici*, *Sal volatile narcotinum*, and by ſome *Sal album alchymiſtarum*. This is made ſometimes with the *Caput mortuum* of Vitriol, and ſometimes

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the loſs of about half its weight of phlegm. It continues a perfect Salt, and is by no means changed, as Stahl ſuppoſes, to an earth.

Borax, rendered fluid by fire, diſſolves moſt kinds of earthy bodies and metallic calces, more readily and more perfectly than alcaline or other Salts: the moſt compact crucibles do not long ſuſtain its action. Nevertheleſs a ſlight glazing with Borax is ſaid to defend the veſſel for ſome time from being corroded by glaſs of Lead, as well as by filing its pores to prevent the abſorption of any particles of metals melted in it.

The glaſſes which Borax forms with earths are, in general, very hard and compact, and, when newly prepared, of great brightneſs and tranſparency. On long expoſure to the air, they are apt, like Borax itſelf, to become cloudy; and, if its proportion is very large, opake.

(*u*) *Makes Gold pale.*] This effect is prevented by the addition of Nitre or Sal ammoniac, or the colour of the Gold reſtored, by remelting it with either of thoſe Salts.—I have obſerved likewiſe, that it renders Braſs and Princes-metal pale, the Borax acquiring a deep reddiſh hue; that it gains a like colour on being melted with Copper, and a darker blackiſh from Iron.

ſometimes with Oil of Vitriol.——Three pounds of the *Caput mortuum* or Colcothar of green Vitriol, are elixated with ſix or ſeven quarts of boiling water, and the filtered liquor mixed with a ſolution of two ounces of Borax in a quart of boiling water. The mixture ſuffered to ſettle for twelve hours, and poured off clear from the ſediment, is evaporated to two pounds or a quart, then put into a glaſs body, and treated with a gradual fire: a fine ſparkling Sublimate ariſes, which, after the veſſels have grown cold, is to be ſwept out with a feather. If the phlegm which comes over be returned on the reſiduum, a little more Sublimate may be obtained, and this repeatedly for a ſecond and a third time.——The method of preparing the Salt with Oil of Vitriol is, to diſſolve two ounces of Borax in a quart of water, gradually drop into the ſolution one ounce of Oil of Vitriol, evaporate about one third of the mixture, and then diſtil and cohobate as before.——This Salt was firſt diſcovered by Mr. Homberg, and is uſed by the French phyſicians in fevers and ebullitions of the blood, in deliria, convulſions, hypochondriacal and hyſterical affections. Its particular nature is as yet unknown: it has no volatile ſmell, or pungent taſte, and appears to be of the neutral kind.

BORAX.

I have prepared this Salt by a more commodious method than that of Homberg, without ſublimation or diſtillation. A ſolution of Borax being mixed to ſaturation with a ſolution of Alum, the earth of the Alum precipitates: the remaining liquor evaporated to a certain pitch and ſet to ſhoot, yields firſt fine cryſtals, the ſame with the ſublimed flowers. If the proceſs be continued, the cryſtals which ſhoot afterwards are found to be of a different kind.——A further account of Borax, and enquiries into its nature and properties, may be ſeen in Pott's *Obſervationes & animadverſiones chemicæ collect.* ii. and Modell's diſſertation *de Borace nativa à Perſis* borech *dicta*.

SECT. IV.

BITUMINOUS SUBSTANCES.

Bitum. BITUMENS are inflammable mineral bodies, not ſulphureous, or only caſually impregnated with Sulphur. They are of various degrees of conſiſtency, and ſeem in ſome meaſure to correſpond in the mineral kingdom, to the oils and reſins of the vegetable. There is a perfectly fluid, thin Bitumen, or mineral Oil, called *Naphtha*, clear and colourleſs as Cryſtal, of a ſtrong ſmell, extremely ſubtile, ſo light as to ſwim on all known liquors, ſpreading to a vaſt ſurface on water and exhibiting rainbow colours, highly inflammable, formerly made uſe of in the compoſition of the ſuppoſed inextinguiſhable Greek fire. Next to this in conſiſtence is the *Oleum petræ* or *Petroleum*; which is groſſer and thicker than *Naphtha*, of a yellowiſh, reddiſh, or browniſh colour, but very light, ſo as to ſwim even on Spirit of Wine. By diſtillation, the Petroleum becomes thinner and more ſubtile, a groſs matter being left behind: it does not eaſily ariſe, nor does it totally loſe its colour by this proceſs, without particular managements or additions.

Naphtha.

Petroleum.

Their natural hiſtory. Both Naphtha and Petroleum are found plentifully in ſome parts of Perſia, trickling through rocks, or ſwimming on the ſurface of waters. Kæmpfer gives an account of two ſprings near Baku, one affording Naphtha, which it receives in drops from ſubterraneous veins, the other, a blackiſh and more fetid Petroleum, which comes from mount Caucaſus; the Naphtha is collected for making varniſhes; the Petroleum is received in pits, and ſent to Sjamachia, Baku, Media, Hyrcania, Uſbeck, Circaſſia, and Dageſtan, for lamps and torches: from this place alone are ſaid to be exported daily eight or ten thouſand batmans, each batman amounting to about nine

Dutch

Bitum.

Dutch pounds. A further account of the bituminous tracts in that part of the world, and of burning land, *&c.* may be ſeen in the author above-mentioned, and in the Breſlau collections. Native Petrolea are found likewiſe in Italy, particularly in Lombardy and the Modeneſe; and an inferior ſort, of a ſtrong diſagreeable ſmell, and ſharp bitter taſte, at Gabian in Languedoc: Alſace, Neuchatel, and ſeveral other places in Europe, afford alſo Petrolea. Some years ago, a bituminous earth and Petroleum were diſcovered in the Electorate of Hanover. In the ſhops we meet with no genuine Petrolea; what is ſold under the name both of white and Red Petroleum, being an artificial compoſition, conſiſting chiefly of the oil of the pine-tree, drawn over perhaps from bricks after the ſame manner as the *Oleum philoſophorum*, or diſtilled in an open fire without addition. The Dutch ſell us an *Oleum terræ*, as it is called, of a ſtrong ſmell, and tranſparent reddiſh brown colour, brought in large earthen jars from the Eaſt Indies, and ſaid to be uſed there in palſies: even this however does not ſeem to be a native Bitumen, any more than the officinal *Oleum petræ.* The officinal ſort, diſtilled from bricks, greatly reſembles it. The true Naphtha is recommended againſt diſorders of the nerves, old pains, cramps and contractions of the limbs, for diſcuſſing tumours, *&c.*

Thick Bitumens.

There are Bitumens of a middle conſiſtence betwixt fluid and ſolid; as that called in England Barbadoes Tar, ſaid to drop from certain rocks in America. A thick adheſive Bitumen of this kind is plentiful in Auvergne in France, and proves rather incommodious than uſeful: it exudes on the ſurface of the earth, ſticks to the feet like pitch, and is there called Devil's dung. Such alſo is the *Bitumen judaicum*, which is found on the ſurface of the dead ſea, and ſaid to be raked off by the neighbouring inhabitants before it has been hardened by the ſun.

Solid Bitumens.

There are ſundry Bitumens perfectly dry and ſolid, as Amber, Ambergris, Pit-coal, Jet. In the Pruſſian

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ſian Pomerania we have a bituminous earth, which proves an excellent fuel, eaſily taking fire, burning long, yielding no unpleaſant or prejudicial, but rather an agreeable ſmell, ſomewhat like that of Amber, and leaving only a ſmall quantity of perfectly white aſhes. Turf and Peat belong alſo to this claſs, as being chiefly a bituminous earth, and yielding, when firſt ſet on fire, a diſagreeable bituminous ſmell; though originally compoſed, in great part, of the roots of vegetables (*x*). The learned Dr. Degner of Nimmägen has written an expreſs treatiſe on this ſubject, to which I refer. Sea-water and certain ſprings are likewiſe impregnated with bituminous matter, as we ſhall ſee hereafter in treating of water.

I. AMBER.

AMBER.

AMBER, *Succinum*, called by the Greeks *Electrum*, and by the Arabians *Carabe*, from its power of attracting ſtraw and other light bodies when rubbed, is a ſolid Mineral Bitumen; not as ſome have ſuppoſed, a vegetable reſin, or inſpiſſated juice, introduced into cavities in the earth, and there indurated and ſomewhat changed in its quality; nor a true

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(*x*) *Peat.*] There are very conſiderable differences in Peat, proceeding perhaps wholly from different mineral admixtures, for the ſubſtance of the Peat is plainly of vegetable origin, whence it is found to anſwer for the ſmelting of ores, and the reduction of metallic calces, nearly in the ſame manner as the coals of wood. Some ſorts yield in burning a very diſagreeable ſmell, which extends to a great diſtance; whilſt others are inoffenſive. Some burn into grey or white, and others into red ferrugineous aſhes. The aſhes yield, on elixation, a ſmall quantity of alcaline ſalt, with ſometimes one and ſometimes another ſalt of the neutral kind.

The ſmoke of Peat does not preſerve or harden fleſh like that of wood; and the ſoot, into which it condenſes, is more diſpoſed to liquefy in moiſt weather. On diſtilling Peat in cloſe veſſels, the ariſes a clear inſipid phlegm, an acid liquor, which is ſucceeded by an alcaline one, and a dark coloured oil. The oil has a very pungent taſte; and an empyreumatic ſmell, leſs fetid than that of animal ſubſtances, more ſo than that of mineral bitumens: it congeals in the cold into a pitchy maſs, which liqueſies in a ſmall heat: it readily catches fire from a candle, but burns leſs vehemently than other oils, and immediately goes out upon removing the external flame: it diſſolves almoſt totally in rectified ſpirit of wine into a dark browniſh red liquor.

true marine production, though ſometimes found in the ſea. AMBER.

Its natural hiſtory. It is met with plentifully in regular mines in ſome parts of Pruſſia: the upper ſurface is compoſed of ſand, under which is a ſtratum of loam, and under this a bed of wood, partly entire, but chiefly mouldered or changed into a bituminous ſubſtance: under the wood is a ſtratum of vitriolic or rather aluminous mineral, and under this another bed of ſand, in which the amber is found. Strong ſulphureous exhalations are often perceived in the pits. Helving relates, that wherever there is Amber, there is always a bituminous earth and foſſil wood, a gravelly matter, Vitriol, Nitre, and Sulphur; and that the matter of the Amber reſides in the foſſil wood. The obſervation appears to be juſt, except in regard to Nitre, which is never found in the Amber pits; ſome aluminous matter was doubtleſs miſtaken for Nitre. Conſiderable quantities are met with alſo in the ſea near the Amber ſhores, particularly after a ſtorm; the ſea having probably waſhed out the mineral from the earth.

The principal Amber pits are in the territory called Sandlande, between Pillau and Fiſchhauſen, near the villages Groſshubenick, Groſsdirſchken, Warnicken, Strobſchner, Rittener, Palmnick, &c. The ſhores on which Amber is chiefly fiſhed for are thoſe called Krecke, Nodens, Laſſnick, Knick, Krapellen, Krackſtepellen, Crimichen, and Thieſkim or Bruſterort. The manner of fiſhing for it is pretty well deſcribed in Hartmann's *Hiſtoria Succini Pruſſici*. The digging of Amber is a very dangerous work; the ground not being ſtony or rocky as in metallic mines, but ſandy or loamy, and hence very ſubject to fall in when hollowed underneath. His Pruſſian Majeſty receives a large annual revenue from this commodity; he has a peculiar council called the Amber-chamber; and no one but thoſe appointed for that purpoſe is permitted to dig or fiſh for Amber in his dominions.— Small quantities of Amber are met with alſo in ſundry

AMBER. dry other places; in Bohemia, Sileſia, Saxony, Hungary, France, &c. The pieces of Amber now and then found in theſe places were not, perhaps, originally produced, but left there by the flood.

Subſtances incloſed in it. Various kinds of ſubſtances are often incloſed in maſſes of Amber; as drops of water, which fall to this ſide and that upon moving the maſs; ſmall bits of wood, moſs, leaves of plants, &c. a variety of inſects, particularly gnats, flies, ſpiders, ants, moths, butterflies, graſshoppers, bees, worms, cantharides, caterpillars, crickets, maggots, lice, and fleas. There are ports alſo of frogs, vipers, fiſhes, and other large animals being found in maſſes of Amber, and ſuch are figured in Mercatus's *Metallotheca*; but moſt of theſe are artificial preparations; even the fiſh in Amber, in his Pruſſian Majeſty's repoſitory, is manifeſtly factitious. In my own poſſeſſion there are two hundred ſpecimens of Amber, every one of which has ſomething incloſed. It is evident from hence, that this Bitumen has once been in a fluid ſtate; though we cannot conclude that it ever was a liquid or oily matter, and acquired its conſiſtency and ſolidity by degrees. Appearances are rather contrary to this ſuppoſition. The inſects found in Amber have nothing of thoſe ſtrained or diſtorted poſtures which animals are naturally thrown into upon endeavouring to diſengage themſelves when entangled in a viſcous liquid. We often ſee pieces of Amber in which there are perfect flies with the wings and feet beautifully expanded as if they were ſtill flying. It is moſt probable, that the Amber was generated inſtantaneouſly from the concourſe of mineral oil or petroleum with vitriolic acid, in the form of vapours: which at once concreted together, and embalmed the inſects that happened to lie in their way, with a more durable and precious covering than has ever fallen to the lot of the moſt magnificent monarchs.——A bituminous wood is to be conſtantly met with in the Pruſſian Amber pits: this however does not appear at all neceſſary to the formation of Amber. Amber is found

Produced from Petroleum and vitriolic acid.

found in Italy; where there is no foſſil wood, but plenty of mineral oil or petroleum.

Different ſorts.

There are different ſorts of Amber in regard to external appearance; opake and tranſparent; white or whitiſh, yellowiſh or yellow, greeniſh, browniſh, bluiſh, reddiſh, or browniſh red: what is called black Amber is no true Amber, but a bitumen of the Pit-coal, aſphaltum or jet kind. Some divide Amber into native and factitious: I have ſeen artificial maſſes indeed reſembling Amber in appearance; but no true Amber has hitherto been produced by art. In Holland a vegetable reſin, whoſe proper name is *Gummi de Loock*, is ſold under the name of American Amber: this, when in conſiderable maſſes, and by itſelf, is eaſily diſtinguiſhed from the genuine Amber, by its having leſs electricity, wanting the peculiar ſtrong ſmell which Amber emits in burning, by its greater ſolubility in Spirit of Wine, and not yielding the ſame principles as Amber in diſtillation: ſmall pieces of the reſin mixed among true Amber are more difficultly diſcovered, and this abuſe is not unfrequently practiſed.

Sophiſticated with a vegetable reſin.

Natural differences

Amber is divided by the workmen into different ſortments, according to the ſize of the maſſes; the ſmalleſt and coarſeſt bits are called *Sandſtein*, the ſomewhat larger *Schlug*; thoſe which are ſtill larger, *Firniſs*, or Varniſh Amber; the pieces which are large enough to be turned into beads, or other ornaments or utenſils, are named from the works for which they are judged to be fit. There are other diviſions taken from the quality of the maſſes. Of the opake Ambers, the moſt valuable is the flaky or ſcaly; next to this, the undulated or waved; and next in order the cloudy, the cauliflower or pearl-like, the milky, the citron yellow, the wax-coloured, the dark yellow, the browniſh, and the dark brown, which laſt is the coarſeſt of all. The tranſparent Ambers are divided into reddiſh, gold yellow like a yellow glaſs, citron yellow, pale yellow, and whitiſh. Of all theſe there are ſeveral ſubdiviſions, commix-

AMBER. tures, or intermediate ſhades; and ſometimes we meet with pieces of other colours, as greeniſh, bluiſh, coffee-coloured, opal-coloured, &c. With regard to the tranſparent Ambers, it may be proper to take notice, 1. That inſects or other foreign bodies are obſerved chiefly in theſe; poſſibly they may often be lodged alſo in opake Amber, though the opacity of the maſs prevents our ſeeing them. 2. That opake Amber is capable of being made tranſparent by art; and hence that all our tranſparent Ambers were not naturally ſuch. 3. That the fine gold yellow tranſparent ſort is entirely natural; the common methods of improving the tranſparency, weakening the colour. There are means of communicating to Amber a variety of colours: an excellent artiſt at Breſlau, by name Gottlieb Samuelſon, not only made opake Amber tranſparent, but tinged it red, blue, violet, of a purpliſh, green, and white; and cut it into brilliants, necklaces, ear-pendents, bracelets, &c. in imitation of precious ſtones; as alſo into ſpectacles, microſcopes, priſms, burning lens's, &c. of which an account may be ſeen in the Breſlau collections. 4. That Amber clarified by art is always harder, and leſs electric, than in its natural untranſparent ſtate.

Embelliſhed by art.

Clarification.

Schroder relates, that yellow Amber is made white by boiling in ſalt-water; and later writers have copied this account: on trial, however, ſalt-water is not found to have any ſuch effect. The workmen have two methods of clarifying Amber: one by ſurrounding the Amber with ſand in an iron pot, and cementing it with a gradual fire for forty hours; ſome ſmall pieces placed near the ſides of the veſſel, being occaſionally taken out for judging of the effect of the operation: the ſecond method, which is that moſt commonly practiſed, is, by digeſting and boiling the Amber about twenty hours with Rapeſeed oil, by which it is rendered both clear and hard: treated in the ſame manner with Linſeed oil, it does not become clear. Sendelius informs us that he clarified pieces of cloudy Amber, by applying them to the flame of a candle, and rubbing them now and then with tallow; and that opake pieces, boiled with fiſh and with fleſh, ſhewed a diſpoſition to become clear. The moſt deſirable point in the manufactures of Amber would be, to find a method of melting ſmall pieces into a large one; but nothing of this kind has hitherto been diſcovered.

Enquiry into ſolvents for it.

It is no ſmall piece of art to procure a total ſolution of Amber. I have tried twenty-five different methods; with alcalies, acids, oils, inflammable ſpirits, dulcified ſpirits, balſams, and other menſtrua; without being able perfectly to ſucceed. Hoffmann relates, that he has diſſolved Amber in two ways: one is, by putting two parts of oil of Almonds and one of powdered Amber into a glaſs veſſel, and ſetting the veſſel in Papin's digeſter filled about one third with water: the cover of the digeſter being ſtrongly ſecured, and a moderate fire kept up for above an hour, the Amber was reſolved into a tranſparent gelatinous maſs, on the ſurface of which floated a little fluid oil. The other method is, by boiling powdered Amber in water with an equal weight of cauſtic Nitre; this corroſive alcali occaſioning, as he ſays, almoſt all the Amber to be diſſolved. Theſe experiments I leave to their own merit, but muſt obſerve, that neither of them afford ſuch ſolutions as I was in ſearch of. Henckel has carried the affair much farther, pretending to prepare Amber, without burning, and without alcalies, ſo as to diſſolve totally in Spirit of Wine: of this aſſertion we can form no judgment till the fact is produced. Of the common menſtrua, there is not one which totally diſſolves this concrete: in Papin's digeſter, the Amber perhaps is only ſoftened. Moſt liquors however extract ſome portion of it: a tincture made in vinous ſpirits is kept in the ſhops. Some have thought to promote the action of the ſpirit by fixed or volatile alcaline Salts; but theſe kinds of additions give very little, if any, aſſiſtance to the ſpirit as a menſtruum, and are

AMBER. accompanied with an inconvenience of rendering the tincture unfit for the chirurgical uſes to which it is commonly applied. Highly rectified Spirit of Wine extracts of itſelf a ſufficiently ſtrong tincture from Amber: the admixture of alcaline ſalts deepens the colour of the liquor, without increaſing the quantity taken up. If the ſimple tincture is required to be more ſaturated with the Amber, it may be eaſily rendered ſo by drawing off a part of the ſpirit, which may be reſerved for the like uſes again, as being impregnated with the more ſubtile parts of the Amber. If the ſpirit be totally abſtracted, a balſamic or reſiniform extract is left: this is employed by ſome as an ingredient in compoſitions for pills. Water mixed with the tincture renders it turbid, but ſcarce any precipitation enſues; though in ſeveral books of pharmacy a magiſtery of Amber is directed to be prepared by this means.

Diſtillation. Amber melts and burns in the fire, and emits a ſtrong peculiar ſmell. Diſtilled, in a ſtrong heat, it yields a phlegm, an oil, and a particular ſpecies of volatile ſaline matter. The diſtillation is performed in earthen or glaſs retorts, frequently with the addition of Sand, powdered Flints, Bricks, Lime, elixated Aſhes, Bole, Loam, Pumice, Sea-ſalt, Coals, *&c.* Conſiderable differences are obſerved in the products, according to the additions made uſe of: with ſome the Salt proves yellowiſh and dry, with others, browniſh or blackiſh, and unctuous or ſoft like an extract: with ſome the oil is throughout of a dark brown colour; with others it proves externally green or greeniſh; with elixated aſhes in particular, of a fine green, as I have found on repeated trials. The quantity of oil and phlegm is greateſt when coals, that of Salt when Sea-ſalt is uſed. The moſt common addition is ſand; of which two parts are mixed with two or one of Amber in coarſe powder, the mixture put into an earthen retort, of which it may fill ſomewhat more than one half, the neck of the retort wiped clean, the veſſel placed in a reverberatory furnace,

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nace, a receiver luted on ſo as that the neck of the retort may reach down into its body, and the fire cautiouſly increaſed, leſt the Amber, melting like pitch, ſhould boil over into the recipient: at firſt a phlegmatic liquor diſtils, then a fluid oil, afterwards a thicker and more ponderous, and laſt of all, an oil ſtill more ponderous along with the Salt. Amber may be very commodiouſly diſtilled alſo without any addition, in glaſs retorts coated or uncoated; only greater caution is here required in the management of the fire, as the Amber is more apt to ſwell up and boil over by itſelf, than when divided by earthy or other matters: the recipient ſhould be large, and the retort only half filled with the Amber. Thoſe whoſe ſole buſineſs it is to diſtil Amber in Pruſſia, and whom long experience has taught the moſt advantageous methods of doing it, uſe no addition. The Engliſh chemiſts likewiſe diſtil their Amber without addition, and ſell the reſiduum to the japanners, who prepare from it the fineſt black varniſh. Hoffmann directs Amber-varniſh to be made by melting the Amber and pouring it on an iron plate, then pulverizing, and putting it into a crucible, adding Linſeed oil that has been prepared with litharge, and laſtly pouring in Oil of Turpentine till the whole is diſſolved: the Engliſh method of making varniſh from the *Caput mortuum* is certainly more frugal than the melting of good Amber on purpoſe. The *Caput mortuum* of Amber diſtilled *per ſe* was in my experiments conſiderably light and ſpongy: when it looks like Colophony, we may preſume that there has been ſome miſmanagement in the proceſs; that either the fire has been too haſtily raiſed at firſt, or not ſufficiently continued.

Salt.

In order more perfectly to collect the Salt, which is the moſt valuable product in this operation, the Pruſſian workmen frequently change the receiver during the diſtillation, and keep apart the phlegm and the light oil which ariſe at firſt. They purify the Salt by placing it for a time upon bibulous paper,

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which abſorbs a part of the oil; and changing the paper ſo long as it receives any oily ſtain. Where a further depuration is required, (for by this method we only ſeparate a part of the oil that adheres externally) the Salt is to be ſcraped out as clean as poſſible from the neck of the retort, or wherever elſe it has concreted, and waſhed of with water. The whole diſtilled matter is then to be mixed with a conſidera-quantity of hot water, the mixture well ſtirred together with a wooden ſpatula, the water, after ſettling, poured off, and freſh parcels of hot water added, to extract all the ſaline matter that may be retained by the oil: the Salt ſeparated at firſt is to be diſſolved in this liquor, the ſolution filtered, evaporated in glaſs veſſels to a proper pitch, and then ſet in the cold: the Salt will ſhoot into fine ſpongy yellow cryſtals, which may be gently dried upon bibulous paper: the remaining liquor may be further inſpiſſated and cryſtallized afreſh, or evaporated to dryneſs: the Salt obtained by theſe laſt proceſſes will turn out browner and browner, and is therefore to be reſerved for inferior purpoſes, or further purified, by repeating the ſolution, filtration, and cryſtallization. I have freed the Salt by way of curioſity, ſo far from its oil, that it looked white as ſnow.

Salt of Amber, though it ariſes in diſtillation, and is diſtinguiſhed by the name of a volatile Salt, is not to be confounded with the volatile Alcalies. It is truly an acid Salt, changes Syrup of Violets red, efferveſces with and neutralizes alcalies, and precipitates ſubſtances diſſolved in them. The *liquor cornu cervi ſuccinatus* of the ſhops is no other than a neutral ſaline liquor compoſed of this Salt and volatile alcalies: the method of preparing it in the greateſt perfection is, to diſſolve pure Salt of Amber and Salt of Hartſhorn ſeparately in diſtilled water, and add the alcaline ſolution to the other by a little at a time, till the ſaturation is compleated: by this means we obtain a neutral ammoniacal Salt of a peculiar kind. The nature and qualities of Salt of Amber are as yet

very

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very little known. Its acid ſeems to approach neareſt to the vitriolic; for Oil of Vitriol, which expels the nitrous, marine, and acetous acids in form of fumes from alcalies or earths with which they have been combined, extricates no vapour from Salt of Amber, nor from combinations of it with alcaline Salts. When fixed alcalies however have been neutralized with Salt of Amber, and reduced into cryſtals, they ſtill efferveſce with the vitriolic acid; which, if the acid of Amber was truly vitriolic, they could not do (*y*).

(*y*) *Salt of Amber.*] Though Oil of Vitriol unites with this acid Salt without efferveſcence or fumes, it does not follow that its acid is of the vitriolic kind. Oil of Vitriol, dropt on Tartar, is imbibed with equal quietneſs, yet no one preſumes from hence, that the acid of Tartar is vitriolic . . . . Mr. Bourdeline endeavours to prove, that the acid of the Salt of Amber is marine.* A genuine Sea-ſalt is indeed obtainable from ſome ſorts of Amber, as I have oftener than once obſerved; but this does not affect the volatile Salt of the Amber, the Sea-ſalt being equally procurable after the ſeparation of the volatile Salt, and the volatile Salt giving no marks of any thing marine. As large quantities of this Bitumen are found in the ſea, we need not be at a loſs to account for its accidental impregnation with marine Salt . . . . Mr. Pott † has given a curious ſet of experiments upon this ſingular Salt; from which its acid plainly appears to be eſſentially different from the three mineral acids, and to approach neareſt to thoſe of the vegetable kingdom. We ſhall here give an abſtract of the principal obſervations he has made upon this Salt.

Salt of Amber requires a large quantity of water for its ſolution. In the firſt cryſtallization it ſhoots into ſpongy flakes, in colour reſembling brown Sugar-candy: the cryſtals which ſucceed prove darker and darker coloured. On repeating the depuration, the firſt cryſtals appear at top of a clear yellow or whitiſh colour, in form of long needles or feathers; at bottom darker and more irregular, as are likewiſe the cryſtals which ſhoot afterwards. The cryſtals neither liquefy nor become powdery in the air: rubbed, they emit a pungent ſmell like that of radiſhes, eſpecially if warmed a little; their taſte is acid, not in the leaſt corroſive, but with a kind of oily pungency.

This Salt kept in the heat of boiling water loſes nothing of its weight, and ſuffers no alteration. In a great heat it melts like oil; after which, a little oily acid liquor ariſes, then oily ſtriæ appear in the lower part of the retort, and the Salt ſublimes into the neck, partly in the form of a dark yellow butter, and partly in that of feathers, a black coaly matter remaining at the bottom; ſo that by this proceſs a part of the Salt is deſtroyed.

Oil of Turpentine has no action on this Salt. Highly rectified Spirit of Wine gains from it a yellow colour in the cold, and on the application of heat diſſolves a conſiderable quantity, but depoſites great part of it on cooling: the Salt thus depoſited is ſomewhat whiter than before,

* Mem. de l'acad. de Sciences de Paris. An. 1742.

† Mem. de l'acad. de Sciences de Berlin. An. 1753.

We very rarely meet with any genuine Salt of Amber in the ſhops; powdered Amber, Creme of Tartar, Sugar, Sal ammoniac, Sea-ſalt, and other ſub-

fore, but ſtill continues ſenſibly yellow. The dulcified or vinous Spirit of Sal ammoniac diſſolves it readily, without effervеſcence, into a yellow liquor: if the Salt was foul, the ſolution proves of a red colour: on burning off the vinous ſpirit, a neutral liquor remains.

A ſolution of Salt of Amber in water, ſaturated with a pure fixed alcaline Lixivium, yielded on inſpiſſation a ſaline matter, which would not cryſtallize, and which, when exſiccated by heat, deliquiated in the air, leaving a conſiderable portion of an unctuous earthy matter: being again gently inſpiſſated, it left a browniſh Salt, very ſoluble, weighing one half more than the Salt of Amber employed: this Salt effervеſced with the nitrous and vitriolic acids: the vapour which exhaled was not acid, but ſomewhat ſulphureous and oily. On repeating the experiment, and fully ſaturating the Alcali with the Salt of Amber, the neutral Salt made no effervеſcence with thoſe acids. This Salt did not perfectly melt before a blowpipe: continued in the fire for ſome time, it effervеſced with Aqua fortis, a mark that it had now loſt ſome of its acidity. In diſtillation it yielded a bitter oily alcaleſcent ſpirit, much reſembling the Spirit of Tartar; and towards the end an empyreumatic oil: the reſiduum elixated, yielded the alcaline Salt again of a a brown colour.

Salt of Amber mixed with volatile ſpirits, raiſes a ſtrong effervеſcence, and after ſufficient ſaturation, forms with them a neutral, ammoniacal, oleaginous liquor; which totally ariſes in diſtillation in a fluid form, except that a ſmall portion of a penetrating oily ſaline matter concretes towards the end.

On diſtilling Salt of Amber with an equal quantity of common Sal ammoniac, an acid marine ſpirit came over, of a very ſtrong ſmell, and a brown colour: afterwards a little white Sal ammoniac ſublimed: at length aroſe ſuddenly a large quantity of a fuliginous or bituminous matter, leaving behind a ſmall portion of a like ſhining black ſubſtance. The coaly matter was conſiderably more in quantity than the Salt of Amber employed.——On treating it with Nitre, red nitrous vapours aroſe, and then the mixture detonated with violence . . . . . A mixture of it with Borax frothed and ſwelled up much more than Borax by itſelf, and on raiſing the fire, yielded only ſome oily drops; the acid being deſtroyed by this Salt, as by fixt Alcalies and Quick-lime.

Spirit of Sea-ſalt poured upon one fourth its weight of Salt of Amber, made ſcarce any ſolution in the cold: on the application of heat, nearly the whole coagulated into the conſiſtence of a jelly. In diſtillation the Spirit of Salt aroſe firſt, then almoſt the whole of the Salt of Amber, partly like firm butter, partly like long ſtriated plumous Alum, very pure, and of a fine white colour, its oily matter being changed into a coal at the bottom. The Salt thus purified, makes no precipitation in ſolution of Silver, and conſequently retains nothing of the marine acid, nor does it precipitate ſolution of Quick-lime, made in Spirit of Salt, and conſequently contains nothing vitriolic. If any of the mineral acids was contained in this Salt, it could not here eſcape diſcovery; the oil, which in the rough Salt is ſuppoſed to conceal the acid, being in this proceſs ſeparated.

Aqua fortis poured upon one fourth its weight of Salt of Amber, extracted a yellowiſh colour in the cold, but diſſolved little: on the application of heat, the whole diſſolves into a clear liquor without any coagulation;

Amber.

ſubſtances, being commonly mixed with it, and a good quantity of oil left in it, the better to conceal theſe additions.

Oil.

The Oil of Amber is rectified by diſtilling it over, either by itſelf or with different additions, as burnt Bones, Lime, elixated Aſhes, Chalk, tobacco-pipe Clay, Pot-aſh, *&c.* The beſt method is to diſtill it with common water, and repeat the diſtillation ſeveral times with freſh parcels of water: by this method we obtain a clear limpid oil, a large quantity of thick pitchy matter remaining behind. I have rectified Oil of Amber to ſuch a degree, that ſcarce any one could tell what kind of fluid it was, as it mingled with water, with Spirit of Wine, with an acid, with expreſſed oils, with diſtilled oils, and almoſt with all liquors. Spirit of Wine digeſted with the unrectified oil, does not diſſolve it, but extracts ſome of its finer parts, leav-

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coagulation: if the Salt is very oily, the ſolution proves red. In diſtillation, greateſt part ariſes in a liquid form, with only a ſmall matter of concrete Salt. The ſpirit does not act upon Gold, but diſſolves Silver and Quickſilver as at firſt; a proof that it has received no marine acid from the Salt of Amber.

Oil of Vitriol being added to twice its weight of Salt of Amber diluted with a little water, a moderate fire elevated an acidulous liquor, which appeared to proceed from the Salt of Amber; for its making no change in ſolution of fixed Sal ammoniac ſhewed it not to be vitriolic. On continuing the diſtillation by a ſtronger fire, greateſt part of the Salt ariſes undeſtroyed, and the oil of Vitriol along with it, a black, light porous earth remaining.

Equal parts of Quick-lime and Salt of Amber gave over in diſtillation only an acidulous phlegm: the reſiduum, elixated with water, yielded a ſolution of the Lime in the acid of the Amber, reſembling a ſolution of the ſame earth in vegetable acids, precipitable by alcaline Salts and by the vitriolic acid. Lime added to a watery ſolution of Salt of Amber, diſſolves with ſome effervescence, after which the whole coagulates into the conſiſtence of a jelly: this diluted with warm water, proves ſimilar to the foregoing ſolution.

Solution of Salt of Amber makes no precipitation in ſolutions of Silver or Quickſilver. It diſſolves Zinc, as all acids do: fixed Alcalies precipitate the Zinc: the volatile do not, and when a ſufficient quantity of the volatile has been added, the fixed make no precipitation. It acts exceeding ſlowly and difficultly upon Copper, but corrodes calcined Copper in a ſhorter time. It ſoon corrodes Iron by coction, into a Crocus, and diſſolves a part into a liquid form: the ſolution has little colour, but alcaline Salts readily diſcover that it holds Iron, by rendering it turbid and whitiſh, and throwing down a conſiderable quantity of a greeniſh calx. A ſolution of this Salt does not appear to act upon Lead or Minium by long digeſtion; and in this reſpect it differs from the vegetable acids.

AMBER. ing a conſiderably thick pitchy ſubſtance. —— In the ſhops it has been cuſtomary to impregnate volatile ſpirits with Oil of Amber, by mixing powdered Amber with the ingredients from which they are diſtilled: commonly one part of Amber, one of Sal ammoniac, and three of Quick-lime, are mixed together, and committed to diſtillation with a proper quantity of Spirit of Wine. Theſe *ſuccinated Spirits of Sal ammoniac* or *Sal volatile oleoſum ſuccini*, may likewiſe be made extemporaneouſly, by diſſolving rectified Oil of Amber in the vinous Spirit of Sal ammoniac prepared with Quick-lime.

Quantities of Salt and Oil. Different ſorts of Amber differ greatly in the produce of Salt and Oil. Sixteen ounces of the common coarſe untranſparent Amber found in the ſea (the ſort generally made uſe of in the ſhops) yielded ſomewhat more than eleven ounces and ſix drachms of Oil, four drachms and a half of Salt, nearly an ounce and a half of water, and ſcarcely an ounce of *Caput mortuum.* Hartman relates, that white Amber yields more Salt than the yellow; that from a pound of the firſt he obtained four drachms, and from the ſame quantity of the latter only one. Another Pruſſian obſerves, that the *Sandſtein* yields moſt Salt, the *Schlug* leſs, and the *Ferniſs* ſtill leſs. I am informed by a friend, that from a pound of the *Sandſtein* he has gained from ſix drachms to an ounce of Salt; but I preſume the Salt was either very oily, or was diſtilled with additions. I repeated the experiment on that kind of Amber with great care, and obtained from thirty-two ounces, nine drachms of good pure Salt, and nearly twenty-four ounces of Oil.

II. AMBERGRIS.

AMBERGRIS. Natural Hiſtory. AMBERGRIS, *Ambragriſea*, is a marine Bitumen, about the conſiſtence of wax, of a laminated ſtructure, as if the maſs was formed by a ſucceſſive appoſition of matter, ſometimes found in the waters of the ſea, ſometimes thrown out upon the

AMBERGRIS.

the ſhores, and ſometimes met with in the ſtomachs of whales and other fiſhes, frequently intermixed with little bones, claws of birds, and other like matters. Theſe circumſtances have given riſe to many ridiculous opinions concerning its origin, as its being the excrement of birds or fiſhes, generated in the ſtomachs of fiſhes like Bezoar, being a ſort of wax produced by bees upon rocks, *&c.*

Extraordinary pieces

The greateſt quantities of Ambergris are met with in the Eaſt-Indies, about the iſland Madagaſcar, the Molucca iſlands Mauritius and Neykotarres, the weſtern Sumatra iſlands, about the iſland Borneo and Cape Commorin, near Malabar, and on the Ethiopian coaſt, which, from Solafa to Brana, is ſaid to be very rich in Ambergris. Pieces are ſometimes met with of an extraordinary ſize. Chevalier and Garcias mention a piece weighing no leſs than three thouſand pounds, found in 1555 at Cape Comorin, and ſold for Aſphaltum; and Joh. Hugo von Lindſchott informs us, that a maſs of thirty quintals was found at the ſame Cape. Monardes and Franciſcus Hernandez mention a piece of an hundred pounds; Garcias, one as large as a man, and another which was ninety palms in length and eighteen in breadth; Montanus, one of a hundred and thirty pounds; and Kempfer, one exceeding that weight, found in his time in the province of Kinokuni in Japan. The Dutch Eaſt-India company purchaſed of King Tidori in 1693, for eleven thouſand rixdollars, a piece of Ambergris weighing one hundred and eighty-two pounds, which was kept many years at Amſterdam, and ſeen by thouſands, but afterwards broken and ſold by piece-meal: it was of the ſhape of a tortoiſe, and meaſured five foot eight inches by two foot two: Nicholas Chevalier has given a particular deſcription of it in a treatiſe printed at Amſterdam in 1700. Mr. Godfrey, a chemiſt in London, informed me that a merchant there had a maſs of ſix hundred ounces, and that another had one of ſixty pounds.

AMBERGRIS, Differences. Ambergris is of various colours, aſh-coloured, whitiſh, yellowiſh, blackiſh-grey, brown, black, ſtreaked, and ſpotted. The pieces which have been ſwallowed by fiſhes are the leaſt eſteemed, as receiving an ill ſmell from the animal. The quite blackiſh and the quite whitiſh are to be rejected; and thoſe which are ſmooth and of an uniform texture, we may ſuſpect of being counterfeits. The aſh-grey-coloured Ambergris, with whitiſh, blackiſh, and yellowiſh ſtreaks or ſpecks, is accounted the beſt, eſpecially when intermixed with beaks of birds, bits of cuttle-bone, or other like matters; not that theſe are eſſential to the Ambergris, but as they are marks of its genuineneſs. General properties. The beſt Ambergris is light, like wax to the touch, crumbly, yet ſomewhat tenacious, ſo as to ſtick to the mortar or peſtle; it has an agreeable ſmell, but no remarkable taſte; it eaſily melts in the fire, takes flame from a candle, and burns away without intermiſſion.

Sophiſtications. Ambergris is counterfeited or adulterated with Wax, Reſin, Storax, Benzoine, Amber, Labdanum, Muſk, Civet, Aloes-wood, old decayed Aſh-wood, Rice, Meal, Tree Moſs, and other like ſubſtances. Theſe abuſes are eaſily detected. The counterfeit ſorts are commonly uniform throughout, both in colour and texture, like a paſte or maſs of pills, which the genuine Ambergris never is. The former commonly ſoften ſooner in the warm hand, and never have the true Ambergris ſmell, no art being able to perfectly imitate this. The ſmell is moſt readily diſtinguiſhed in melting the Ambergris on burning coals, or in a Silver ſpoon over a candle or in the flame: it ſmells at laſt like burning Amber, but not ſo ſtrong. The true Ambergris bubbles up in melting, and after fuſion appears brown. Some judge of its genuineneſs, from the appearance of a matter like melted Reſin upon piercing the maſs with a red-hot needle, or other ſlender inſtrument. Menſtrua likewiſe afford ready methods of diſtinguiſhing the genuine from the ſophiſticated.

AMBERGRIS.

Chemical characters. Solution.

Ambergris melts in boiling water like a Reſin, and communicates to the liquor a little of its ſmell, which ariſes along with the water in diſtillation. It diſſolves in Linſeed oil if the Ambergris be previouſly melted, and the oil freed from water. It has been hitherto looked upon as exceeding difficultly, and not at all totally ſoluble in Spirit of Wine; the Spirit being ſuppoſed to extract only a ſmall part, as it does from Amber. I have found however, that this Menſtruum may be made to diſſolve Ambergris both readily and totally. If Ambergris, broke in pieces, be put into twelve times its weight of a good tartarized Spirit of Wine, or of a plain highly rectified ſpirit; the ſpirit will extract little till it begins to boil, but will then quickly diſſolve the whole of the Ambergris except its impurities. If the ſpirit is impregnated with any eſſential oil, whether by drawing it over from oily vegetables, or by adding the oil itſelf, it will diſſolve Ambergris more readily, and in a leſs degree of heat than would otherwiſe be neceſſary: I have tried likewiſe the rectified Oil of Amber, and found that this, as well as the vegetable diſtilled oils, promoted the action of the ſpirit; but that expreſſed oils, recommended by Schroder, had no effect. The tincture made in tartarized ſpirit is of a deep reddiſh colour; that made in pure ſpirit has ſcarcely any colour. The reſiduum appears of a large volume, though when dried, it proves to be only a very ſmall quantity of a fine earthy matter, amounting, when the Ambergris is free from viſible impurities, to a grain or two upon two ſcruples. It is probable that Ambergris has often been diſſolved, though the paleneſs of the ſolution, and apparent bulk of the reſiduum, have induced the operator to think otherwiſe. In keeping the tincture or ſolution, if the veſſel is looſely ſtopt, ſo as to ſuffer a part of of the Menſtruum to exhale, a proportionable quantity of the Ambergris precipitates, in form of a white unctuous ſubſtance like tallow, ſoluble again

upon

AMBERGRIS. upon adding more ſpirit. Lemery looked upon this as wax, and hence endeavoured to prove that Ambergris proceeded from the labour of bees. —— The dulcified Spirits of Vitriol, Nitre, and Sea-ſalt, and the dulcified or vinous Spirits of Sal ammoniac made both with Quick-lime and with fixed alcaline Salts, digeſted with Ambergris, did not diſſolve it, and extracted extremely little: it was obſerved that in the digeſtion with dulcified Spirit of Vitriol, and with this only, the little it did extract concreted about the ſides of the glaſs into ſmall ſaline cryſtals.

Diſtillations. Dr. Grimm gives an analyſis of Ambergris by diſtillation in the *Ephemerides naturæ curioſorum.* An ounce diſtilled in a glaſs retort, yielded firſt an aqueous liquor, then as he calls it, a ſpiritual liquor, afterwards a yellow oil with a ſmall quantity of volatile Salt, a pitch-like matter remaining in the retort. He obſerves, that the liquor, the oil, the ſalt, and the reſiduum, were all ſimilar to thoſe obtained from Amber, except that the oil was in ſmell more agreeable. —— I repeated this experiment with a drachm of Ambergris, and obtained the ſame products, except as to the pitchy reſiduum, ſcarcely one grain of duſt or earthy matter being here left, probably from the fire having been longer continued or raiſed higher than in Grimm's experiment. The quantity of oil was two ſcruples and a half, of phlegm five grains, and of Salt two grains. Both the oil and the ſalt agreed with thoſe of Amber.

The analyſis of Ambergris confirmed me in the opinion that this concrete, whoſe origin was formerly ſo much diſputed, is truly a Bitumen of the Amber kind; and accordingly I communicated my obſervations to the Royal Society in London, in the year 1729. The facts were called in queſtion by ſome of the Engliſh chemiſts; and about three years after, Sir Hans Sloane ſent me an account of the experiments made by Mr. Brown and Mr. Godfrey. The former diſtilled Ambergris with tobacco-pipe clay, and obtained, firſt a clear phlegm, next a ſpirit in colour

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colour reſembling beer, afterwards a darker coloured oil, and at laſt a black balſam: the oil and balſam were nearly the ſame with thoſe of Amber, but no volatile Salt was obtained. Mr. Godfrey made three diſtillations of Ambergris, one by itſelf, another with ſand, and the third with powdered glaſs. On rectifying the liquors diſtilled with ſand, he had more than half the weight of the Ambergris, of a limpid, balſamic, and bituminous oil, with a phlegm which taſted ſouriſh, but leſs ſo than Vinegar.

Theſe experiments, inſtead of being, as was ſuppoſed, contrary to mine, are entirely agreeable to them, and manifeſt a ſtrong reſemblance betwixt Ambergris and Amber in regard to their conſtituent parts. The difference of the ſeveral experiments is this: I obtained from ſome pieces of Ambergris a ſmall portion of a volatile acid Salt; the piece examined by Mr. Brown yielded no concrete Salt; Mr. Godfrey's yielded no Salt, but an acidulous liquor, which was a ſolution of the Salt in phlegm.

Uſes.

Ambergris is uſed principally as a perfume, in balſams, ſnuffs, dentifrices, hairpowders, waſhballs, *&c.* It was formerly held in ſome eſteem as a medicine, and ſaid to poſſeſs nervine, analeptic, aphrodiſiac, cephalic, and other virtues, but is at preſent little regarded. A tincture of it is ſometimes prepared with ſpirit of Roſes: this Spirit has no advantage as a menſtruum for the Ambergris above ſimple Spirit of Wine, though it may in ſome caſes be an uſeful addition in point of ſmell, ſolutions of Ambergris by itſelf having very little ſmell (*z*).

(*z*) *Additional article.*] In the Swediſh Tranſactions for the year 1743, there is an account of another kind of marine Bitumen, which was found in conſiderable quantity in Finland, of a white colour, reſembling tallow, but more brittle; in ſmell ſomewhat like roaſted meat. It feels unctuous, makes paper greaſy, ſwims on water, burns with a fine blue flame and copious ſmoke, and leaves a blackiſh brown ſubſtance like Reſin, flexible betwixt the teeth, and not ſoluble by the ſaliva. Held over the fire it melts, becomes immediately brown, and ſeparates into a thin part like oil, and a thicker which ſticks to the veſſel: both adhere firmly to the veſſel when grown cold. Oil of Almonds does not act upon it in the cold: by the aſſiſtance of a boiling heat it diſſolves greateſt part. Strong tartarized Spirit of Wine diſſolves it; but

what

JEWS PITCH.

Jews Pitch.

Where found.

Sorts.

JEWS PITCH, *Aſphaltum*, *Bitumen Judaicum*, *Bitumen Babylonicum*, is found in a ſoft or liquid ſtate on the ſurface of the Dead-ſea, and by age grows dry and hard. The ſame kind of Bitumen is met with likewiſe in the earth, in other parts of the world, in China, America, and in ſome places of Europe, as the Carpathian hills, France, Neuchatel, *&c.* There are ſeveral kinds of Jews Pitch in the ſhops, but none of them are the genuine ſort, and have little other title to their name, than their being artificially compounded by Jews. They are all firm, ſolid, and of a blackiſh colour, but different in degree of colour. I examined three ſorts, the blackiſh-brown native Bitumen, the beſt officinal ſort, of a blacker colour and ſomewhat bright, and an inferior one, black and gloſſy like common Pitch.

Experiments on the true Aſphaltum

The native Bitumen has no ſmell. It is not acted upon by water, nor highly rectified Spirit of Wine, nor oil Olive, nor the eſſential oils of Aniſeed or Turpentine. In the fire it grew red-hot, like Turf or a piece of red-hot Iron, and when cold, fell into powder. Held over the fire in a proper veſſel, it did not melt, but crumbled as before, and emitted a vapour

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what is remarkable, the circumſtance on which the ſolution of Ambergris in that menſtruum depends, impedes the ſolution of this concrete: as ſoon as the ſpirit begins to boil, a part of the Bitumen falls undiſſolved to the bottom. The ſolution has little colour: in evaporation the Bitumen is depoſited all round the veſſel, nearly in its original appearance.

Specific gravities of ſundry Bitumens.

The above white marine Bitumen	0,770
Ambergris	0,782
Tranſparent yellow Amber	1,085
Jet	1,180
Staffordſhire Pitcoal	1,240*
Newcaſtle Coal	1,270†
Scotch Coal	1,300‡
Aſphaltum	1,400‖
Water	1,000

* Oxford Society. † Mr. Labelye. ‡ Boyle. ‖ Boyle.

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vapour which took flame on the approach of a piece of lighted paper. Four ounces diſtilled in a glaſs retort, yielded only three drachms of an empyreumatic oil, with a little phlegm: the oil greatly reſembled the native Petrolea, but had ſomewhat more of the empyreumatic taint. The *Caput mortuum* weighed three ounces and a half: two ounces of this were reduced by calcination to one ounce and ſix drachms; which yielded, on elixation with water, ſeven grains of an alcaline ſubſtance but not a pure alcaline Salt. It was obſervable in the diſtillation, that the bituminous or oily matter, in ſeparating from the earthy parts, viſibly melted, and then aroſe in inviſible vapours, whereas in open veſſels, there was no appearance of fuſion, the oil immediately exhaling in the air.

on the beſt officinal Aſphaltum

The beſt officinal Aſphaltum has a diſagreeable ſmell, like that of Garlic or Aſa fetida. A ſmall portion of it is taken up by rectified Spirit of Wine, above two ſcruples of ſpiritous extract being obtained from two ounces. Water diſſolves nothing, but elevates a part of its Garlic flavour in diſtillation. It diſſolves both in oil of Olive, and in the diſtilled oils of Aniſeed and Turpentine, and unites in the fire with Pitch and Wax. Diſtilled Vinegar and and Spirit of Salt have no action on it, the Aſphaltum ſwimming untouched on the ſurface. It gives a yellowiſh tinge to Spirit of Nitre, and partly ſwims on the ſurface, and partly falls to the bottom. It gives a deeper tincture to Spirit of Vitriol, and totally ſwims. It ſinks in cauſtic alcaline Lixivia, and tinges them yellowiſh, but floats on ſimple alcalies, and to theſe alſo communicates a tincture. Vinous Spirit of Sal ammoniac ſeems to extract the deepeſt colour; the watery ſpirit gains but a very ſlight one: in the former, the Aſphaltum totally ſinks, in the latter a part of it ſwims. Four ounces yielded in diſtillation two ounces five drachms and one ſcruple of oil, and only about two ſcruples of phlegm, above an ounce of *Caput mortuum* remaining. The oil was thickiſh, JEWS PITCH.

of a dark brown colour, and had a ſtrong ſmell and taſte like thoſe of Garlic: it ariſes firſt in white, then in yellow, and at laſt in darker coloured vapours: as ſoon as the yellow fumes appeared, the matter in the retort begun to melt. Nothing ſaline appeared in the diſtillation or could be extracted by hot water from the oil, or from the calcined *Caput mortuum.*

on an inferior ſort.

The inferior Pitch-like Aſphaltum melted as eaſily as common Pitch. From four ounces I obtained almoſt full three ounces of dark brown oil, and a ſmall portion, about half a ſcruple, of phlegm, the reſiduum making up the fourth ounce: ſcarce any thing ſaline could be diſcovered in the reſiduum by calcination and elixation with water. Two ounces being digeſted in rectified Spirit of Wine, the filtered liquor left on diſtillation fifteen grains of extract: the ſpirit drawn over ſmelt of Garlic or Aſa fetida. Whilſt another parcel was digeſting in rectified Spirit, no viſible ſolution being made, I dropt in an eſſential oil; it was oil of Savin that came firſt to hand: the ſpirit now begun to act, and by the time an hundred drops had been added, appeared conſiderably tinged: the quantity of Aſphaltum was a ſcruple, and of ſpirit two drachms. The ſolution was here effected by virtue of the oil, and not of the ſpirit: for upon digeſting another ſcruple of the powder with a drachm of the oil of Savin, nearly all the Aſphaltum was ſoon diſſolved: on adding rectified Spirit of Wine, it was thrown down again, and the ſpirit ſcarcely appeared tinged.

From theſe experiments it is evident, that the officinal Aſphalta are very different from the genuine natural bitumen; and as they are a medly of we know not what ingredients, their medicinal uſe begins to be deſervedly laid aſide, notwithſtanding the diſcutient, reſolvent, pectoral, and other virtues, attributed to this bitumen by the ancients. The Aſphalta of other countries appear to be as little genuine as ours: in Du Hamel's hiſtory of the French Academy of Sciences, we find that two pounds of the

French Aſphaltum yielded fourteen ounces of oil; from whence we may preſume, that this was one of the oily artificial compoſitions, the native Aſphaltum not affording one fourth ſo much.

JEWS PITCH.

Uſes.

This bitumen was formerly uſed in embalming the bodies of the dead. At preſent the thick and ſolid bitumens are employed in Egypt, Arabia, and Perſia, as Pitch for ſhips; as the fluid ones, for burning in lamps, and for varniſhes. Some writers relate, that the walls of Babylon, and the temple of Jeruſalem, were cemented with Bitumen inſtead of mortar. Thus much is certain, that a true native Bitumen, that for inſtance which is found in the diſtrict of Neuchatel, proves an excellent cement for for walls, pavements, and other purpoſes, uncommonly firm, very durable in the air, and not penetrable by water. The watch and clockmakers uſe a compoſition of Aſphaltum, fine Lamp-black, and oil of Spike or Turpentine, for drawing the black figures on dial-plates: this compoſition is prepared chiefly by certain perſons at Augſburg and Nurenberg.

IV. PIT-COAL.

PIT-COAL.

Natural Hiſtory.

PIT-COAL, *Carbo foſſilis*, *Anthrax*, *Lithanthrax*, is a bituminous foſſil, found in ſeveral parts of the world, moſt plentifully in England and Scotland, from whence it is exported, in large quantities, into other countries, for the common purpoſes of fuel. The moſt conſiderable Coal-pits are in the neighbourhood of Newcaſtle, and the coals dug here are likewiſe accounted the beſt, though ſome of the Scotch ſorts render their ſuperiority diſputable. Some other parts of England, as Somerſetſhire, Staffordſhire, &c. afford alſo plenty of Coals. Next to the Engliſh and Scotch, the French are held to be the beſt, particularly thoſe of St. Etienne foreſt, and Auvergne: there are Coals likewiſe in other parts of France, as Burgundy, Nivernois, &c. thoſe of St. Dizier are the worſt. In Kircher, the German ephemerides, the Breſlau collections, PIT-COAL. lections, &c. we find accounts of Pit-coal dug in the iſland Elva, in Sicily, and in different places of Italy; between Neuſol and Chremnitz; in the dutchy of Würtemberg; at Altdorff near Nuremberg, and at Kalterſnortheim on the river Fulda in Eiſenach; in the iſland Bornholm, in Bohemia, Heſſia, Saxony, &c. It is ſaid that there are external marks, by which the tracts of land that abound with Pit-coal may be diſtinguiſhed: that the ground itſelf is either manifeſtly bituminous, or ſeldom has any Dew: that the Snow melts ſooner than in other places: that the trees are ſmall, and that their roots contain a bituminous juice: and that the air, in hot ſummer weather, is highly ſulphureous.

Different ſorts. There are many different ſorts of Pit-coal; light and heavy; ſpongy and compact; brittle and firm; earthy and ſtony; of a more or leſs diſagreeable ſmell in burning: the vapour of all the ſorts is generally diſagreeable to thoſe who are unaccuſtomed to it. The French divide Pit-coal into two kinds, which they diſtinguiſh by different names: the light and brittle are called *Charbons de terre*, Earth-coals; the ponderous and compact, *Charbons de pierre*, Stone-coals. Jet. There is a hard light ſort, very compact, ſmooth and equal; not ſtaining the fingers like thoſe commonly uſed for fuel; capable of being poliſhed, filed, cut, and turned in a lathe; uſually made into ſnuff-boxes, bracelets, and other elegant toys; called *Gagates* and *Succinum nigrum*, jet or black Amber. The fineſt of this kind is met with in England, particularly in Staffordſhire and in Cornwall. This appears to be a ſpecies of Bitumen diſtinct from the common Pit-coal, and to be rather a bituminous Wood than an original Bitumen: it looks like fine black ebony. In the fire, it ſooner catches flame than the common Coals, and burns rather with a bituminous than ſulphureous ſmell. Some pieces, in which the woody matter prevails, ſmoke but do not flame: theſe are not to be looked upon as a Bitumen of this ſpecies. See Boyle's treatiſe on the origin of gems.

PIT-COAL.

Marks of goodneſs.

The beſt Coals are thoſe which ſooneſt take fire, burn longeſt, and give the greateſt heat. The characters laid down in the Œconomical lexicon as marks of good Coals, their emitting a black ſmoke, yielding a watery moiſture on being preſſed, and not burning without bellows or ſtrong wind, are marks not of good, but of the bad German Coals. Good Pit-coal yields a thick yellowiſh ſmoke, gives out nothing upon expreſſion, unleſs moiſtened, and burns without any ſtrong impulſe of air.

Experiments.

The beſt ſort of the Halle Pit-coal, digeſted and boiled in Water and in rectified Spirit of Wine, gave out nothing conſiderable to either. Forty-eight ounces, diſtilled in a glaſs retort, with a fire gradually increaſed, yielded two ounces ſeven drachms of phlegm; two ounces and one drachm of a thin fluid oil; and one ounce of a thick, tenacious, ponderous, pitchy oil, which ſtuck in the neck of the retort: the reſiduum weighed forty-one ounces ſeven drachms. Nothing of the acid Salt like that of Amber, which Hoffman obtained from Pit-coal, was here diſcovered: the diſtilled liquors gave marks rather of an urinous and ammoniacal matter, changing Syrup of Violets greeniſh, and emitting an urinous odour on the admixture of fixed alcaline Salts or quicklime. The *Caput mortuum*, calcined and elixated with Water, yielded a ſmall portion of ſaline matter, not alcaline but rather aluminous, a ſolution of it being rendered turbid by fixt alcaline Salts, and depoſiting an earthy precipitate. The Oil aroſe in yellow fumes, and ſmelled conſiderably ſulphureous; it ſomewhat ſtained poliſhed Silver, but the ſtains were eaſily rubbed off: that which diſtilled at firſt was light, and ſwam on Water; the ſucceeding parcels proved more and more groſs and ponderous, and at laſt ſunk. The Coals, during the diſtillation, looked like melted pitch. — The coarſe ſtony Pit-coal of Halle yielded no oil: from two ounces were obtained only a drachm of liquor, of a ſtrong ſulphureous ſmell; and about half a drachm of a yellow ſublimate, greatly

PIT-COAL.

reſembling common Sulphur: the reſiduum weighed one ounce, ſix drachms and a half.

Uſes and inconveniencies.

Pit-coal, an excellent fuel for common uſes, is for many purpoſes unfit. It cannot be employed for the running down of Iron or other ores, which are ſmelted in contact with the fuel; not, as ſome have ſuppoſed, that the foſſil Coal does not give ſufficient heat; but from its ſulphureous ſubſtance corroding and ſcorifying the metal, or rendering it brittle; whilſt vegetable Coals ſupply only the ſimple inflammable principle neceſſary for receiving the metal into its metallic form. Thoſe which are in any conſiderable degree ſulphureous, render Iron brittle even on the blackſmith's forge. Nor are foſſil Coals proper for fuſion in crucibles, as they melt and cake about the veſſel, and endanger its cracking: the glaſs-makers in England have been greatly diſtreſſed by this ill quality of Pit-coal, and the ſcarcity of wood; inſomuch as to proffer a reward of ten thouſand pounds to thoſe who diſcovered a compoſition for pots that ſhould beſt ſtand Pit-coal fires. — In Brabant, Liege, Cologn and other places, the ſmall Coals, which would burn away too ſoon or fall through the grate, are commonly reduced into powder, mixed with loam, and formed into cakes or maſſes, which are employed with good advantage for the ſame purpoſes as large Coals. — The ſmoke of Pit-coal has been generally ſuppoſed prejudicial to health: Hoffman appears to be the firſt who has maintained the contrary, and I am entirely ſatisfied of the juſtneſs of his opinion. I never obſerved the leaſt prejudice from them during my long reſidence in London; and it may be obſerved, that even when we are immediately expoſed to the ſmoke, it does not affect the eyes like the ſmoke of wood.

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SECT.

SECT. V.

WATER.

WATER is an univerſal fluid, diſtributed in abundance through all the kingdoms of nature, but referred moſt properly to the mineral, from its being collected in ſuch immenſe reſervoirs in the earth. It is diffuſed through the atmoſphere in the warmeſt and drieſt weather: alcaline Salts grow moiſt in the air in the greateſt droughts: metallic veſſels, cooled by the application of the ice or ſnow and made thoroughly dry, collect watery drops on being brought into a warm air, by condenſing the aqueous vapours that imperceptibly floated in it.

WATER
Diffuſed through all the kingdoms of nature.

Water is the baſis of all liquids. Not only acid, alcaline, vinous Spirits, but Oils themſelves, owe to Water their liquid ſtate. It is an ingredient in the compoſition of all animal and vegetable bodies, even of their hardeſt and moſt ſolid parts; as alſo in that of all minerals, unleſs the precious ſtones and pure metals be exceptions. Some of the cryſtalline Salts in particular, as green Vitriol and Alum, though ſolid, hard, and to appearance perfectly dry, are found upon experiment to abound with Water, and to loſe their ſolidity and cryſtalline form upon ſeparating their Water, whether by the force of fire, or more gradually by the natural gentle warmth of the atmoſphere. When Water is conſidered as entering the compoſition of bodies, or extracted from them by art, it is commonly called by the chemiſts phlegm.

The baſis of all liquids, &c.

There is a conſtant is circulation of Water from one region of nature to another. This fluid is continually exhaling by the ſun's heat, from the ſurface of the ocean, from rivers, ſprings, and ponds, from the earth, from animals and vegetables, into the air; and being there accumulated, and condenſed, deſcends

Conſtant circulation of water.

WATER descends again, in rain, ſnow, hail, and dew; affording freſh ſupplies to the mineral ſources, to the animal and vegetable worlds. By this uninterrupted circulation, the fluid itſelf is preſerved from putrefaction; and all the ſublunary creation recruited with ſucceſſions of ſweet Water.

Carries off fixt bodies in its exhalation.

Water exhales more eaſily from ſome ſubſtances than from others; from Stones, Sands, Bolar-earths, Reſinous woods, more eaſily than from ſaline, unctuous, gelatinous, mucilaginous juices, and ſlimy earths: hence there are ſoils which retain moiſture longer than others. It carries off in its exhalation ſundry ſubſtances, which of themſelves would not ariſe: ſome bodies, which by themſelves abide fixed and unaltered in the moſt intenſe degrees of fire, vitriolated Tartar for inſtance, exhale into the air along with the vapour of boiling Water. The air receives alſo an infinity of effluvia from fires, mineral works, putrefactions, and other natural or artificial reſolutions of bodies. Hence the atmoſpherical Waters, though purer than the ſubterraneous, are by no means perfectly pure or elementary.

Atmoſpherical waters.

The atmoſpherical waters are obſerved to be more fertilizing to the earth than any others. Collected with due precaution, and preſerved from any foreign taint, they do not putrefy; though the Rain-waters caught in towns, in ciſterns, in gutters of houſes, ſoon corrupt. To obtain rain, Snow or Hail-water in their greateſt natural purity, they ſhould be collected in clean glaſs veſſels, in an open field, at a diſtance from towns or houſes, at a time when the air is pure, not when the Rain or Snow begin, nor till a conſiderable quantity has fallen, that the lower air may be firſt waſhed from ſuch heterogeneous matters as may have floated in it. Dew, collected on clean linen clothes ſtretched, in clear Weather, at ſome diſtance above the graſs, appears to be one of the pureſt of the natural Waters; though Boerhaave makes Hail-water the pureſt, and next to it that of Snow; accounting dew to be the moſt impure of all, to be a chaos of different exhalations from the earth: ſuch indeed it may be, when gathered immediately from plants, but not when obtained with the precautions above-mentioned. The dews of May, and the rains of March, are held to be the pureſt; and the rains which fall in ſummer to be the leaſt pure, the air being in this ſeaſon commonly loaded with animalcula or their eggs. The rains which accompany thunder appear to receive no peculiar quality from that circumſtance: the æthereal vivifying ſpirit, which ſome have ſuppoſed them impregnated with, is merely imaginary.

Common waters.

The Waters found in the earth or upon its ſurface are divided into ſweet and mineral; the firſt including thoſe which are perfectly inſipid and anſwer for the common purpoſes of life; the other, thoſe which have a manifeſt taſte, and are impregnated with ſaline or other mineral matters. Of the ſweet Waters, that of ſprings, when truly ſweet, is the pureſt. The beſt Spring-water is that which runs through open, hilly, rocky, ſandy, gravelly countries: the Waters which iſſue from black mould, in low and ſhady grounds, is greatly inferior. Spring-water is divided into four kinds: *aqua ſcaturiens* or *viva*, ſuch as naturally bubbles up at the ſurface of the earth: *aqua fontana*, ſuch as is lodged deeper, and which, when diſcovered by digging, is encloſed and raiſed by a pump: *aqua putealis*, Spring-water uninncloſed, or in open wells or ciſterns: *aqua ſaliens*, Spring-water conveyed by pipes. All theſe Waters are at bottom the ſame, and differ only in being more or leſs ſubject to accidental impurities after their diſcharge from the ſpring. Not to mention the duſt, animals, &c. which open wells are liable to receive; even the Waters conveyed by pipes may corrode ſome of the matter of the pipe or its cement, and thus contract diſagreeable qualities. I have examined the aqueducts at Rome, thoſe between Marly and Verſailles in France, and thoſe by which London is ſupplied with the New-river

Spring-water.

river Water; and found them to be in ſome places liable to this inconvenience.

River-water.

River-waters are generally ſuppoſed to be purer than thoſe of ſprings, but I cannot agree in this opinion. All Rivers proceed originally from ſprings, and ſurely they are more liable to gain than to loſe impurities in their courſe. What an immenſity of filth do rivers receive from populous towns and manufactures? and even in places remote from towns, what variety of light vegetable and earthy matters is blown into them by every wind? (a) The ſmaller, navigable,

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(a) *Spring and River-waters.*] River-waters, though they ſhould ſeem, from the conſiderations above-mentioned, to be far leſs pure than thoſe of ſprings, are nevertheleſs found, from daily experience, to be the pureſt of the two, or at leaſt to be the beſt adapted to the common purpoſes of life. Spring-waters are very often *hard*, do not boil peas tender, or form a ſmooth lather with ſope, or anſwer for dying, bleaching, waſhing, &c. whilſt thoſe of rivers are in general *ſoft*, and fit for all theſe uſes, almoſt equal with Rain-water.

The hardneſs of Spring-waters has been generally aſcribed to their being impregnated with Sea-ſalt. Dr. Home has ſhewn, in his ingenious eſſay on bleaching, that neither pure Sea-ſalt, nor any of the perfectly neutral Salts, compoſed of an acid and an alcali, give any hardneſs to Water: that the common ſorts of Sea-ſalt make Water hard, by virtue only of the heterogeneous Salt which they retain from the bittern (ſee page 329.) That all acids, and Salts compoſed of an acid and an earthy or metallic ſubſtance, have this effect: and that the offending ingredient in hard Spring-waters is a combination of an acid and earth. Sope is a compoſition of Oil and alcaline Salt: on mixing this compound with ſuch a Water, its alcali is abſorbed by the acid of the Water, upon which its oil, deprived of the ſubſtance that made it miſcible with aqueous liquors, ſeparates and curdles on the ſurface: at the ſame time, the earth of the Water, now forſaken by the acid that held it diſſolved, ſettles to the bottom. It follows from this theory, that alcaline Salts in their pure ſtate will diſcover hardneſs in waters more effectually than ſope, by turning the Water milky or cloudy, and precipitating its earth.

It follows alſo, that by thus precipitating the earth, and neutralizing the acid, they will ſoften the Water; and on trial, they are actually found to produce this deſirable effect: if a ſolution of any fixed alcaline Salt is dropt in by degrees, ſo long as any cloudineſs enſues, and the liquor ſuffered to ſettle till it becomes clear; how hard ſoever the Water was before, it is now found to be ſoft, and fit for all the purpoſes of life . . . . The ſame gentleman obſerves, that hard Waters are indiſpoſed to corrupt, and even preſerve putreſcible ſubſtances for a conſiderable time: whence they ſhould ſeem the beſt fitted for ſea, eſpecially as they may be at all times ſo eaſily ſoftened. It has been ſuppoſed, that navigable, unfrequented Rivers, in ſtony or rocky countries, between hills, full of ſtones, of a rapid courſe, are generally the cleareſt and pureſt.

Pond-waters.

The ſtagnant Waters of lakes, ponds, marſhes, pits, ditches, are the moſt impure of all: as they are open, they are ſubject to extraneous impurities; and as they are ſtagnant, they are diſpoſed to putrefy. The ſmaller the body of Water, the more liable it is to putrefaction.

Mineral-waters.

Mineral Waters may be divided into ſaline, bituminous and noxious. The ſaline Waters are of three kinds, thoſe impregnated with common Salt, the Waters called medicinal, and thoſe whoſe impregnation is too inconſiderable to recommend them to the notice of the phyſician. There are two natural ſolutions of common Salt; Sea-water, and that of ſaline ſprings or brine-pits. The laſt are commonly not only richer in Salt, but more pure ſolutions of it than the firſt.

Sea-water.

Sea-water is naturally clear and colourleſs as common Water; though it ſometimes exhibits greeniſh, yellowiſh, bluiſh, reddiſh, browniſh, blackiſh, and other colours, from accidental admixtures, or agitations of the Water by ſtorms, or different reflexions of the ſun's rays. The ſuperficial parts of the Water are lighter, leſs ſaline, and more coloured, than the lower: while twelve ounces of the ſuperficial Water yielded three drachms of Salt, the ſame quantity taken up for a conſiderable depth, has afforded fifteen grains more. The taſte of Sea-water is not only ſaline, from the common Salt, but manifeſtly bitter.

Bitterneſs of Sea-water ſuppoſed owing to Bitumen.

Count Marſigli endeavours to prove, that Sea-water contains a bituminous matter, from which its bitterneſs proceeds. He obſerves that pure common Salt being diſſolved in Water in the proportion abovementioned, namely three drachms to twelve ounces, with the addition of a ſcruple of Spirit of Pit-coal, the

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that theſe Waters become purer by boiling: but though, in proportion to the evaporation of the fluid, a part of the earth ſeparates and incruſtates on the ſides of the veſſel, the remaining liquor is found to be harder than at firſt.

the liquor was found to have the bitter as well as the ſaline taſte of ſea-water: that a part of the bituminous matter ariſes with the Water in diſtillation, and incruſtates on the ſides of the glaſs in which the diſtilled Water is long kept: that a pound of Sea-water diſſolved two drachms and fifteen grains of Salt beſides what it naturally contained; and that common Water diſſolved more than the Sea-water could be impregnated with.

Owing wholly to bitter Salt.

From theſe and other experiments it is probable, that Sea-water contains a portion of a bituminous ſubſtance, but not that the bitterneſs depends on this ingredient. There are ſundry neutral Salts, as vitriolated Tartar, the *Sal mirabile* of Glauber, the Salts of the purging mineral Waters, which have a very conſiderable bitterneſs, though they contain nothing bituminous; and does not a ſalt of this kind actually exiſt in Sea-water? (See page 329.)

It may be proper to obſerve, that Sea-water contains often a nitrous matter; the acid ſpirit diſtilled from Sea-ſalt proving a menſtruum for Gold, which the marine acid by itſelf never does, and which nothing but the nitrous will enable it to do. Though this however is frequently the caſe, it is not always: I have examined marine Salt, whoſe acid had no action on Gold.

Methods of ſweetening Sea-water.

Different methods have been contrived for ſweetening Sea-water, or freeing it from the Salt, ſo as to render it fit for drinking and for the common uſes of life. Some have endeavoured to ſeparate the Salt in the way of precipitation; but all the known ſubſtances, that are capable of throwing down any of the Salt, are, in part, retained themſelves by the Water, ſo as to communicate to it diſagreeable or dangerous qualities. Others have propoſed filtration through porous ſtones, ſands, and inſipid earths: it appears from experience, that Water, in paſſing through a conſiderable thickneſs of theſe kinds of ſubſtances, will leave great part of its Salt behind, and by repetitions of the filtration, nearly the whole: but the quantity of ſtony or earthy matter requiſite for this purpoſe is much too large, and the proceſs itſelf too tedious, to have place on board a ſhip, where ſuch expedients are principally wanted. Becher mentions a certain pump, contrived by one Walker in England, by means of which freſh Water might at once be pumped up from the Sea: this inſtrument was not only found too expenſive, but wanted durability, and could not be worked on board a ſhip. The beſt method is diſtillation: the only objections to this are, that diſtilled Sea-water does not quench thirſt like common ſweet water, and that the proceſs is too expenſive and incommodious to be practiſed at ſea. The firſt may be eaſily remedied by certain additions, that ſhall abſorb the looſe acid in the Water, and prevent its ariſing: with regard to the other, diſtilling veſſels have been contrived, in which the proceſs may be continued without intermiſſion, in all kinds of weather, notwithſtanding the motions of the ſhip, with little fuel, and at litte expence (*b*). I ſaw, in

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(*b*) *Sweetening of Sea-water.*] This proceſs has of late received notable improvements from the happy induſtry of Dr. Hales. He finds, that the addition of a ſmall proportion of chalk ſerves to prevent any acid from ariſing, and thus renders the diſtilled liquor perfectly ſweet: and that by driving a ſtream of air through the Water in the ſtill, the quantity drawn off proves at leaſt double to what would ariſe in an equal time without that aſſiſtance. By this method, he obſerves, a ſtill which holds twenty gallons will yield, in twenty hours, two hundred and forty gallons of freſh Water, with little more than two buſhels of coals. A ſmall ſtill of five gallons produces ſixty-four gallons in twenty hours. The ſtill may be occaſionally ſupplied with Sea-water by a cock in the head, without loſs of time in unluting it; and that all poſſible advantage may be gained, the Water warmed in the worm tub may be employed for this purpoſe.

It is ſaid that the diſtillation is ſtill further expedited, by dividing the head of the ſtill into a number of partitions, by parallel plates. There is doubtleſs conſiderable room for improvement in the ſtructure of ſtills; but the particular advantage of this conſtruction I do not apprehend. The largeneſs of the ſurface expoſed to the air, or to any other medium leſs hot than the included vapour, will undoubtedly promote its condenſation; but plates within the ſtill head muſt ſoon become equally heated with the vapour itſelf: perhaps, widening the paſſage of the vapour would anſwer better: it is certain that the evaporation of liquids, by an equal heat, is in proportion to the ſurface of the liquor itſelf, and to the freedom of the vapours paſſing off; and that in the common ſtill, the vapour is ſo much obſtructed, as when the heat is raiſed too high, to blow off the head.

the French academy, a drawing of a curious machine of this kind invented by M. Gautier, of which there is ſome account in the Breſlau collections for the years 1717 and 1718. It were greatly to be wiſhed that this proceſs could be introduced into general practice, ſo as to relieve the diſtreſſes to which ſailors are ſo often expoſed, from their water either failing, or putrefying and breeding of worms. Boerhaave informs us, that the Dutch Eaſt India ſhips uſe a ſaline mixture for preſerving their Water ſweet, compoſed of twelve parts of Aqua fortis or Spirit of Nitre, ten parts of clean Rheniſh Tartar, and two parts of purified Saltpetre: theſe ingredients are put into a glaſs body, and digeſted in the heat of a Water-bath till the Salts are diſſolved, after which the liquor is ſtrained and ſet by to ſettle. The Water to be taken in is boiled, an ounce of this ſaline liquor added to every eighty pounds, the boiling continued a little longer, and the Water, when grown cold, filled into caſks.

Preſervation of Water from corruption.

Brine-ſprings.

The ſecond ſort of Waters impregnated with Sea-ſalt is the Brine-water or that of ſaline ſprings: from this, the pureſt common Salt is uſually extracted. The quantity of Salt is different in different ſprings; ſome holding no leſs than three ounces and three drachms upon a pound, and ſome few ſtill more; whilſt others contain leſs than Sea-water does, ſome ſcarce two drachms on a pound. Theſe Waters are for the moſt part a pure brine of common Salt, though ſome of them have alſo an aluminous impregnation (*c*).

Medicinal waters.

The Medicinal Waters, to which alone cuſtom has erroneouſly appropriated the name of Mineral, are impregnated either with vitriolic acid, with the alcaline baſis of Sea-ſalt, with a ferrugineous earth diſſolved

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(*c*) *Brine Springs.——Aluminous impregnation.*] It may be doubted whether any of theſe Springs contain a true Alum. Many of them participate of the bitter purging Salt, which has not unfrequently been miſtaken for Alum, and which in ſome reſpects greatly reſembles it; both Salts bubbling up in the fire, and turning into a light ſpongy unfuſible calx; and both being compoſed of the vitriolic acid combined with an earth: they differ however in many eſſential properties, the earth in one being of a diſtinct kind from that of the other.

WATER

ſolved by the vitriolic acid, or a certain alcaline earth combined with the ſame acid into a bitter purging Salt ſimilar to the *Sal mirabile.* Theſe Waters are commonly divided into *Acidulæ* and *Thermæ*; the firſt comprehending, not really acid waters as the name imports, but all thoſe which are cold; the latter, the hot ones, ſome of which are of a quite ſcalding heat. The hot Waters commonly contain more of a groſs earthy matter, imperfectly diſſolved, than the cold; as appears from the hard ſtony ſubſtance, uſually of a yellowiſh or reddiſh colour, with which the channels of the former are, from time to time, plentifully incruſtated. The methods of examining the contents of particular mineral Waters may be ſeen in Hoffmann's *De acidulis & thermis*, Seip's treatiſe on Pyrmont Water, ſome papers in the French memoirs, *&c.* The principal trials are, 1. Evaporation; by which we not only diſcover the quantity of ſolid matter contained in Water; but at the ſame time, as we here obtain that matter by itſelf, are enabled to determine what it is: by elixating it with pure Water, we obtain the ſaline and the indiſſoluble parts ſeparate from one another. 2. Diſtillation; by which we are enabled to diſcover whether the Water contains any volatile matter, ſaline or bituminous. 3. The admixture of certain liquors; as Syrup of Violets, infuſion of galls, ſolutions of Lead and Silver. Theſe and other liquors exhibit different phænomena according to the ſubſtances which the Water is impregnated with: thus Syrup of Violets is changed red by acids, and green by alcalies; infuſion of galls ſtrikes a black colour with ferrugineous ſolutions, and with theſe only; ſolutions of Lead and Silver, dropt into liquors particitating of Sea-ſalt or vitriolic acid, render them cloudy or turbid, and depoſit their metal combined with thoſe ſaline bodies (*d*).—

Moſt

(*d*) *Examination of Mineral-waters.*] The art of inveſtigating the contents of Mineral waters has been incumbered with a multiplicity of experiments more oſtentatious than uſeful. The phænomena reſulting from the admixture of other bodies with the Water are for the moſt

part

WATER Moſt of the Medicinal-waters undergo an alteration in their compoſition, and loſe their virtue, on being carried

part fallacious; Waters very diſſimilar in quality exhibiting, on theſe kinds of trials, ſimilar appearances. The principal additions made uſe of in this view, and the changes enſuing upon their mixture with different Waters, are as follow.

Syrup of Violets is changed red by Waters impregnated with a pure acid, or with Alum; and green by ſuch as contain a prevailing alcali, a combination of calcareous earth with marine acid, and ſome other compound Salts both earthy and metallic . . *Alcalies* efferveſce with acid Waters, and with ſome of thoſe which contain Salts compoſed of an acid with an earth or metal . . *Fixed alcaline Salts* produce a cloudineſs or milkineſs in Waters impregnated with Alum, with the purging bitter Salt, with the Salt called fixed Sal ammoniac, and in general with any combination of acid and earth: they likewiſe render all metallic ſolutions turbid, and precipitate the metal from theſe, as the earth from the others . . *Volatile alcaline Salts* or Spirits have the ſame general effects as the fixt: with this particularity, that they ſtrike a blue colour with ſolutions of Copper: hence volatile alcalies are of good uſe for diſcovering Copper; and *ſolutions of Copper*, for diſcovering volatile alcalies . . *Sope* is curdled by acid Waters, and by all thoſe which are made turbid by alcalies . . *Solution of Sope* in vinous ſpirits is rendered milky by the ſame Waters . . With all thoſe Waters alſo, a *ſolution of Sulphur* in alcalies or Lime-water, becomes milky, and emits a ſtrong fetid ſmell . . *Acids* effervesce with Waters in which an alcali or earth prevail; and turn all thoſe liquors milky which contain ſubſtances diſſolved by alcalies . . *A ſolution of Silver* in Aqua fortis produces a milkineſs in all that contain an alcaline Salt, Sea-ſalt, fixed Sal ammoniac, bitter purging Salt, Alum, Sal mirabile, or other combinations of the marine or vitriolic acids with alcalies or earths . . *Solution of Mercury* makes all thoſe waters turbid that ſolution of Silver does . . And *ſolution of Lead*, the ſame . . . Upon the whole, experiments of this kind may ſerve to inform us, that certain Waters participate of ſome mineral impregnation, but not to determine what that particular ſubſtance is. I can recollect but two inſtances, in which ſimple mixture affords any degree of certainty; the blue colour from Copper and volatile alcali, and the bluiſh or purple from Iron and ſome aſtringents.

The ſimple and obvious method of analyſing Waters is, to gently diſtil a large quantity in clean glaſs veſſels, and examine the diſtilled liquor and reſiduum ſeparately. 1. The diſtilled liquor is ſometimes found to turn Syrup of Violets red. We may be ſure that this effect proceeds now from a pure acid, and not from a combination of an acid with any other body. 2. The reſiduum conſiſts of a ſaline part ſoluble in pure Water, and an earthy one. By careful cryſtallization, the Salts may be ſeparated from one another, and obtained in their proper form; or they may now be diſcovered with certainty, by means of additions, without ſuch ſeparation.

A prevailing unſaturated alcali is eaſily known, by its raiſing an effervescence with the marine and vegetable acids. The fixed matter may effervesce with the ſtronger acids, and turn Syrup of Violets green, though it contains no alcali.

The other Salts are compoſed of an alcali or earth ſaturated with one or more of the mineral acids . . 1. The baſis or ſubſtance combined with to any conſiderable diſtance, or long kept; though taken up and ſecured with the greateſt precautions, and preſerved in cool cellars. Where theſe medicines, therefore, are had recourſe to, the patient is always to be adviſed to the Spring itſelf: here, beſides enjoying the water in its perfect ſtate, exerciſe, change of air, amuſements, company, freedom from domeſtic cares, will greatly aſſiſt its ſalutary virtue.

Bituminous waters.

Bituminous Waters are thoſe which have a mineral oil or bitumen either floating diſtinct on the ſurface, or intimately diſſolved in ſmaller quantity. There are ſundry Waters which abound with bituminous matter, as near Bologna, in Neuchatel, in the electorate of Hanover, and other places. If we ſeparate from theſe Waters all the bitumen that appears undiſſolved, the Water is ſtill far from being pure. It permanently retains a ſtrong bituminous ſmell and taſte.

Noxious Waters.

The noxious Waters are of three kinds, 1. The petrifying Waters, or ſuch as abound with earthy or ſtony matter, which incruſtates on ſolid bodies kept in the Water, and often ſpontaneouſly ſeparates, eſpecially

with the acid, is found, by adding, to the ſaline ſolution, a ſolution of any pure alcaline Salt. If the baſis is an alcali, no change will enſue from the admixture of its like; but if an earth, it will be precipitated. Spirit of Vitriol, added to the earth, will readily diſcover of what kind it is; this acid diſſolving the aluminous earth into an highly aſtringent liquor; magneſia into a bitter one; and not at all, or not perfectly diſſolving the calcareous. For the greater certainty in regard to this laſt, we may diſſolve the earth in ſome other acid, as Aqua fortis, and then add ſome Spirit of Vitriol, which will precipitate the calcareous earth, and leave both the other earths diſſolved. 2. The ſpecies of acid may be diſtinguiſhed by adding to the dry compound a little ſtrong Spirit or Oil of Vitriol: if the acid is the marine, it will be inſtantly expelled in white, and if the nitrous, in red fumes; but if it is the vitriolic, no change will enſue. The marine acid may alſo be known, by the matter enabling Aqua fortis to diſſolve gold; the nitrous, by its fulminating, when ignited, on the contact of any inflammable matter; the vitriolic, by its precipitating any ſolution of calcareous earth, as of Chalk in Spirit of Salt or Aqua fortis. Alcaline Salts alſo precipitate ſuch a ſolution, but with this difference; that when the liquor has grown milky, a little freſh Spirit of Salt or Aqua fortis will render it clear again if the effect proceeded from an alcali, but make no change if from the vitriolic acid: the precipitate thrown down by the former is a calcareous earth again, by the latter a ſelenites.

pecially on the exhalation of a part of the fluid; whence the *ſtalactitæ*, ſtony icicles, dropſtones, often met with in the caverns of the earth. Some of theſe Waters depoſit their contents in a powdery form; others in that of a crumbly, and others of a very hard ſtony maſs. 2. The vitriolic, cupreous Waters, or thoſe impregnated either with a pure vitriol of Copper, or with a mixt vitriol of Copper and Iron. 3. The directly poiſonous Waters, as the arſenical ones found in mines. A Water may be prepared by the chemical art, which, though nearly inſipid, ſhall be highly poiſonous: but, as this might be abuſed to pernicious purpoſes, I forbear to mention its compoſition.

Properties of pure Water,

We have hitherto given a general view of Waters, as naturally blended with other ſubſtances: we ſhall now conſider the principal properties of the purer kinds of ſweet Water.

its ſpecific gravity,

This fluid is inſipid, inodorous, colourleſs, tranſparent. Its gravity is to that of Gold nearly as one to twenty: Eiſenſchmid, in his diſſertation *De ponderibus & menſuris veterum, &c.* gives an account of the abſolute weight of different ſorts of Water, in winter and in ſummer: he obſerves, that a cubic inch of Spring-water, taken in ſummer, weighs five drachms eleven grains, in winter, five drachms fourteen grains; the ſame volume of River-water, in ſummer, five drachms ten grains, in winter, five drachms thirteen grains; diſtilled Water, in ſummer, five drachms eight grains, in winter, five drachms eleven grains; Sea-water, in ſummer, ſix drachms twelve grains, in winter ſix drachms eighteen grains.

ſubtilty,

Water is an extremely ſubtile fluid, capable of pervading not only the minuteſt veſſels of animals, and vegetables, but, by means of preſſure, the ſolid bodies of metals, even the moſt ſolid and compact of all metals, Gold itſelf. This appears from an experiment made by the gentlemen of the Florentine academy: a hollow golden ball being filled with Water, the

incompreſſibility.

the aperture cloſely ſecured, and the ball ſtrongly preſſed, the Water oozed out in little drops all over the ſurface of the metal; a proof both of the poroſity of the Gold, and of the ſubtility and incompreſſibility of Water. That this fluid, nevertheleſs, contains pores, or vacuities between its particles, is evident from its diſſolving a conſiderable quantity of ſeveral kinds of Salts, without any ſenſible increaſe of its volume. porofity,

In a certain degree of cold, this fluid is converted into a ſolid, hard, tranſparent, elaſtic maſs, capable of being poliſhed like glaſs, and, when reduced to the ſame figure, producing the ſame effects as the magnifying and burning-glaſſes. We may properly, with Boerhaave, look upon Ice as the natural ſtate of Water; and its fluidity to proceed from external warmth, not, as that author alledges, from particles of fire intermixed. If particles of fire confined in bodies were the cauſe of fluidity, quickſilver would neceſſarily contain more fire than Water does, as being more fluid, and more permanently ſo; and yet Boerhaave himſelf admits that quickſilver is far colder than Water. congelation.

In a ſmall degree of heat, it exhales ſucceſſively in vapours, which, caught in diſtilling veſſels, condenſe into water again, unchanged in its quality. The action of air and wind remarkably promote its evaporation, the air imbibing and carrying off the watery particles.——When made to boil, it is found to have received the greateſt heat which it is ſuſceptible of: how ſtrongly ſoever the fire be raiſed after this period, the water will grow no hotter, provided the veſſel is open: hence we are furniſhed with one equal ſtandard degree of heat for the graduation of thermometers (*e*); and the freezing of water affords another. It is obſervable, that if a phial or other veſſel of Water, however thin the glaſs, be kept in boiling exhalation, ebullition,

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(*e*) *Boiling heat.*] Later experiments have ſhewn, that the heat of boiling Water varies according to the purity of the Water itſelf, and the gravity of the atmoſphere.

boiling Water, the Water in the phial will not boil. —In cloſe veſſels where the vapour is perfectly confined, Water may be heated to a conſiderably greater degree than it will receive in open ones, and by this means its activity on certain bodies, or its power of diſſolving them, may be greatly increaſed: hence Papin's digeſtor. But this confinement of the vapour is accompanied with great danger to the byſtanders, the vapour of Water when ſtrongly heated, being extremely elaſtic, ſo as to burſt even an Iron bomb-ſhell with violent exploſion. The extraordinary expanſive power of the ſteam of boiling Water is applied to valuable purpoſes in ſome machines, as particularly in the fire engine.

heated beyond ebullition;

elaſtic vapour;

augments flame;

Water added to burning Wax, Pitch, Reſin, Oil, Fat, or other like ſuſtances, increaſes the flame. Without Water there can be no flame, this fluid being the very baſis of the flame: when Coals, Wood, *&c.* are freed from all humidity, or reduced to a coal, they flame no longer. Not that Water contains in itſelf any thing truly inflammable, or that can ſerve as a pabulum of fire; but from its expanſive vapour proving a vehicle to the inflammable matter of the fuel, and carrying it up in an ignited ſtate. Hence it is obſerved, that in conflagrations, the throwing on of a little Water increaſes the fire.

made hot and cold by mixture.

Conſiderable degrees of heat and cold are producible in Water, by the bare admixture of certain other bodies. By diſſolving in it ſome ſaline ſubſtances, particularly Sal ammoniac and Mercury ſublimate, it becomes notably colder: on the other hand, if Oil of Vitriol be haſtily poured into cold Water, the mixture becomes inſtantly ſo hot, that the glaſs cannot be held in the hand.

As a menſtruum for Salts.

Water diſſolves all Salts, though not all with equal facility, or in equal quantity. It diſſolves moſt eaſily the powder Sugars, and fixed alcalies; next to theſe, ſome of the neutral Salts, as the Sal diureticus, ſoluble Tartar, Sal mirabile, common Salt, Sal ammoniac, *&c.* More difficultly, Nitre, Alum, Sugar of milk; moſt difficultly of all, Borax, Tartar, vitriolated Tartar, Salt of Sorrel. Its action is in general greatly promoted by heat and by agitation: by means of theſe it may be made to take up a larger quantity of moſt kinds of Salts than it is capable of keeping diſſolved when thoſe cauſes are removed: thus if boiling water be ſaturated with as much Salt as it will in that ſtate diſſolve, a part of the Salt will ſeparate as the liquor cools. Boerhaave alledges that Water will not diſſolve any Salt without heat: this is a mere play upon words, for by Water he means Ice. —— When Water is overloaded with Salts by means of heat, the part of the Salt which ſeparates on cooling generally concretes into ſolid maſſes, tranſparent, and of regular figures, and hence called by the chemiſts *Cryſtals*, as having ſome reſemblance in appearance to the ſtones of that name. The author above-mentioned makes cold neceſſary to the cryſtallization of Salts: in this he is miſtaken; for many Salts ſhoot into more perfect cryſtals, if the ſolution is kept in a gentle warmth that the water may ſlowly exhale, than if it is removed into a cold place: the Cryſtals of Sugar, called Sugar Candy, are always prepared in a hot room, and the ſame proceſs is applicable to ſundry other Salts. There are therefore two diſtinct principles of cryſtallization: the one, a conſtant ſucceſſive exhalation of the Water by heat; the other a diminution by cold of that power in the Water by which it held the Salt diſſolved.

Cryſtallization of Salts;

Several chemiſts have given us experiments of the quantity of particular Salts ſoluble in a certain quantity of Water. Theſe experiments agree but ill with one another: one ſays, a pound of Water diſſolves two ounces of Salt-petre, another only ſix drachms: one, that a pound diſſolved an ounce of *Arcanum duplicatum*; another, as much again; one, that a pound of Water would take up no more than ſix drachms of green Vitriol, another that it diſſolved four ounces and more: one, that Water will diſſolve equal its own weight of Epſom Salt; and another that it will not diſſolve half its weight:

quantity of different Salts which it diſſolves;

and the caſe is the ſame in other Salts. I therefore made ſundry experiments of this kind myſelf, and found that one ounce of Water diſſolved two ounces of white powder Sugar, two ounces of brown powder Sugar, nine drachms of white Sugar Candy, nine drachms of brown Sugar Candy, nine drachms of Canary Sugar, one ounce of white Sal diureticus, one ounce of black Sal diureticus, one ounce of Epſom Salt, ſix drachms of Sedlitz Salt, ſix drachms of pure fixed alcaline Salt, half an ounce of white Vitriol, half an ounce of Goſlarian Vitriol, half an ounce of Vitriol of Iron, three drachms and one ſcruple of Sal gem, three drachms of common Spring-ſalt, three drachms of Sea-ſalt, two drachms of Sal mirabile, two drachms of volatile Salt of Sal ammoniac, two drachms of crude Sal ammoniac, two drachms of Pot-aſh, two drachms of Cyprus Vitriol, one drachm and ten grains of purified Nitre, one drachm of antimoniated Nitre, one drachm of Sal prunell, one drachm of ſoluble Tartar, one drachm of the Sal embryonatum, one drachm of the Salt of the Carlſbade baths, two ſcruples and a half of crude Alum, two ſcruples of Sal polychreſt, two ſcruples of the Salt of the Egra waters, half a drachm of *Arcanum duplicatum*, half a drachm of vitriolated Tartar, one ſcruple of Sugar of Milk, one ſcruple of Sugar of Lead, one ſcruple of emetic Tartar, fifteen grains of Borax, ten grains of Salt of Sorrel, five grains of white Tartar, five grains of cryſtals of Tartar.

Super-impregnation of Water with Salts.

It is obſervable, that Water, when ſaturated with one Salt, will ſtill diſſolve a conſiderable portion of another; when ſaturated with this, it will ſtill take up a third, and thus ſucceſſively different ſorts, till ſix, ſeven or more are taken up by the ſame Water. Thus four ounces of Water diſſolve only a drachm and a few grains of Alum, and will not touch any more of that Salt; but the ſame Water will diſſolve five drachms of Salt-petre, after this half an ounce of green Vitriol, then ſix drachms of common Salt, three drachms of ſoluble Tartar, and five drachms of Sugar: it will ſtill take up an ounce of fixed alcaline Salt, though a precipitation now begins, as always happens upon the commixture of alcalies with aluminous and vitriolic ſolutions. In like manner four ounces of Water, ſaturated with half an ounce of Salt-petre, will diſſolve half an ounce of white Vitriol, ſix drachms of common Salt, ſix drachms of Sal ammoniac, half an ounce of ſoluble Tartar, and after all theſe, a whole ounce of Sugar.

Precipitates ſome metallic ſolutions;

Boerhaave obſerves, that there are ſome metallic Salts which Water will not diſſolve, as the thick fluid called Butter of Antimony. Butter of Antimony is a ſolution of regulus of Antimony in marine acid; which acid does not diſſolve that ſemi-metal unleſs the acid is highly concentrated, and, after it has diſſolved it, lets it fall again on being diluted with Water. If he had ſaid, that ſome metallic bodies will not diſſolve in diluted acids, and that when diſſolved in concentrated ones they are precipitated upon diluting the liquor with Water, as Reſins are precipitated from Spirit of Wine, the obſervation had been juſt.

as a menſtruum for vegetable and animal ſubſtances;

Water diſſolves vegetable gums and mucilages, as Gum arabic, cherry-tree gum, *&c.* and extracts the gummy parts of concrete or inſpiſſated vegetable juices, as Myrrh, Ammoniacum; or of entire vegetable matters, as Marſh-mallow roots, Quince-ſeeds, *&c.* It likewiſe readily diſſolves and extracts the gelatinous or glutinous parts of animals; hence ſoups, jellies, glues: bones themſelves are ſoftened, and all but their earth diſſolved by it, in Papin's digeſtor. Cold and hot water produce very different effects on ſome animal matters: the whites of eggs diſſolve or mingle with the former, but are coagulated by the latter and rendered indiſſoluble: ſome other animal matters alſo are rather hardened, than ſoftened or diſſolved, by boiling Water.

its action on oils, varniſhes, &c.

Water does not diſſolve or unite with earths, ſtones, metals, ſulphur, bitumens, nor any mineral body that

WATER is not manifeſtly ſaline; nor vegetable oils or Reſins, or animal fats. — It extracts however ſome of the finer parts of the eſſential oils of vegetables, ſo as to become impregnated with their flavour: hence the ſmell and taſte of diſtilled Waters. Oily and reſinous varniſhes, and oil-paintings, if a little warm Water is ſuffered to lie upon them for ſome time, or if long expoſed to the weather, loſe their luſtre, and are at laſt deſtroyed. The Prince of Heſſe had the roof of his orangery painted at great expence by Dagly, after ſeeing, as a proof of the goodneſs of his varniſh, Water boiled over a coal-fire in a veſſel of varniſhed paper: the varniſh however, which ſtood this teſt, was deſtroyed by the weather in a few years.

On Metals

Cold Water corrodes alſo ſome metallic bodies, Copper, Iron, Braſs, Lead, Tin; as we ſee in the pipes and cocks of water-works, and in ſundry water-machines. It is obſervable, that Iron and Sulphur, on each of which, ſeparately, Water has no conſiderable action, if mixed together and moiſtened with Water into the conſiſtence of pap, grow hot, and even burſt into actual flame. This fluid extracts ſo much from the Regulus and from the glaſs of Antimony, as to become emetic: by ſtanding for a night in a copper veſſel, without heat, it contracts a diſagreeable cupreous taſte. Iron, heated red and quenched in Water, communicates a manifeſt taſte, eſpecially if the extinction is ſeveral times repeated; and Quickſilver boiled in Water is ſaid to impregnate the liquor with the anthelmintic and and other virtues of that mineral. Langelot, by grinding Gold for a length of time, in a particular mill, reduced the metal to ſuch a degree of tenuity as to remain ſuſpended in Water.

and Stones

Stones alſo in certain circumſtances are ſubject to the action of this fluid. How often do we meet with Stones excavated by the dripping of Rain? how ſmooth are they made in rivers by the attrition of the Water? how crumbly do the hardeſt Stones become, by repeated ignition and extinction in Water? All the Stones and Earths which burn into Quicklime, are, in that ſtate, in great part diſſolved by ſimple Water.

By the mediation of other ſubſtances diſſolves all bodies.

The bodies which are not acted on by pure Water, are all diſſoluble in it by the mediation of other ſubſtances; particularly of alcalies or acids. In this light, Water may be called an univerſal menſtruum; and it is the only menſtruum which can deſerve that name. Glaſs, Earths, the hard Stones, Flint, Cryſtal, *&c.* melted with ſeveral times their own weight of fixed alcaline Salt, diſſolve readily in Water along with the alcali, and may be diluted to any degree. Sulphur alſo is made ſoluble by fixed alcalies; and all metallic bodies by the compoſition of Sulphur and alcali, or by acids. Water impregnated with fixt alcali, eſpecially if the alcali is rendered cauſtic by Quick-lime, diſſolves Hair, Feathers, Wool, vegetable Reſins; and reduces oils and fats into Sope. Sundry Oils, Reſins, Balſams, are likewiſe rendered miſcible with Water, by yolk of eggs, Sugar, Almonds, and other ſubſtances. The moſt intimate combination of oil with Water is that effected by fermentation: by this proceſs they are united into one apparently homogene fluid, an inflammable ſpirit. — Water and this ſpirit mingle readily together: but if either of them is previouſly combined with certain other bodies, they either will not unite at all, or not without letting go the ſubſtance which they held before in ſolution. Thus if Water be impregnated with fixed alcaline Salt, inflammable ſpirits, however ſhaken with the ſolution, will not mingle with it, but float diſtinct upon the ſurface. On the other hand, if certain neutral Salts be diſſolved in the Water, the Water will readily mingle with inflammable ſpirits, and throw off the Salt, whence the uſe of vinous ſpirits in promoting the cryſtallization of Salts: and in like manner if reſinous bodies are diſſolved in ſpirit, the ſpirit will let the Reſin go, and unite with Water.

Earth left in diſtillation.

The pureſt of the common Waters leave in diſtillation a conſiderable portion of earthy matter: if the diſtilled Water be diſtilled over again, it leaves a little more earth, and this ſucceſſively for a great number of times. Boyle relates, that an ounce of Water, cautiouſly diſtilled over, in glaſs veſſels, two hundred times, yielded ſix drachms of a white, light, inſipid earth, fixed in the fire, and indiſſoluble in Water. Newton and others ſuppoſe the Water in theſe experiments to be really converted into earth: Boerhaave ſuſpects the earth thus obtained to be no other than duſt that had been floating in the elaboratory; though I have never obſerved ſuch duſt to be white, like the earth left in the diſtillation of Water. If the Water be evaporated in broad, ſhallow, open veſſels, the reſiduum is much leſs than when diſtilled in cloſe ones. Even the Spring-waters which plentifully incruſtate tea-kettles with a ſtony matter, leave little or no earth on being boiled away with a large ſurface expoſed to the air.

elevated in evaporation.

Marks of the purity of Water.

The purity of Water is judged, from its limpidity, and want of ſmell and taſte; from its ſparkling or emitting air bubbles on being poured into a glaſs; from its comparative lightneſs; from its depoſiting no ſediment in ſtanding; from its ſoon growing hot, and ſoon becoming cold again, comparatively with other waters; from its being comparatively warm in winter, and cold in ſummer; from its leaving little or no reſiduum on being evaporated or diſtilled; from its eaſily lathering with ſope, boiling pulſe tender, and bleaching linen white; and from its readily paſſing through the body when drank. To which may be added, that the beſt Waters are thoſe which run through flinty or ſandy grounds, and from eaſt to weſt.

Impure Waters corrected.

Some have endeavoured to correct impure Waters, by boiling, ſuffering them to ſettle, then decanting, and repeating theſe proceſſes ſeveral times: by ſuffering the Water to purefy, then decanting and putrefying it again: by boiling it with waſhed ſand, and afterwards filtering: by boiling it, and after ſettling, adding a little Spirit of Vitriol: by analyſing the Water ſo as to diſcover the offending matter, and then precipitating that matter by its contraries. This laſt method appears to be the beſt and moſt effectual. — With regard to the preſervation of Water, open wooden veſſels ſhould never be employed for that uſe; for in theſe it ſoon corrupts. In glaſs veſſels, well corked down and cemented, good Water will keep for ages. A ſmall addition of Spirit of Vitriol or Spirit of Nitre will preſerve Water from putrefaction: at the time of uſing, the acid may be ſaturated and rendered innocent by a little Salt of Tartar. See page 394.

Preſervation of Waters.

PART II.

CHEMICAL HISTORY OF THE VEGETABLE KINGDOM.

SECTION I.

Of VEGETABLES *in general.*

VEGETABLES. Structure of vegetables.

VEGETABLES are bodies of a regular organic ſtructure, analogous in ſome degree to that of animals. They are furniſhed with a variety of veſſels for receiving, tranſmitting, perſpiring different fluids; with organs by which the aliment they imbibe from the earth, from water, or from the air, is changed into new forms, into juices peculiar to particular plants. No art can prepare or extract from the ſubſtances by which vegetables are ſupported, products in any reſpect ſimilar to thoſe elaborated in the bodies of vegetables themſelves. Diſſimilar plants, nouriſhed by one and the ſame ſoil, ſtill preſerve their ſpecific differences, not only in their external form, but in their intrinſic qualities.

Differences in quality, from ſoil, climate,

There are, however, very conſiderable differences in the quality of one and the ſame plant, from the ſoil, climate, ſeaſon, and other like circumſtances. The finer aromatic herbs, naturally produced in dry, ſandy grounds, if removed into moiſt rich ones, increaſe in bulk, but loſe greatly of their fragrance, as if their active principles were exhauſted in a luxuriance of growth (*a*). Immoderately rainy ſeaſons occaſion a like alteration without change of ſoil. The intenſely bitter Colocynth, a native of Perſia, almoſt entirely loſes its bitterneſs when raiſed on our hotbeds, and grows to ten, fifteen, twenty times its natural ſize (*b*).

VEGETABLES.

When

(*a*) *Exhauſted in a luxuriancy of growth.*] It is a common obſervation, that trees which ſpread luxuriantly into branches, bear little fruit in compariſon of thoſe of the ſame kind which are leſs exuberant: hence art, by ſtunting their growth, increaſes their fertility, and at the ſame time improves the quality of the fruit. Mr. du Humel ſuppoſes, with great probability, that the improvements made by grafting proceed wholly from the check given to the increaſe of the woody part: and hence he infers, that the beſt bearing trees muſt be thoſe where the graft is ſo remote from the nature of the ſtock, as to be but juſt ſupported or kept alive by it.

(*b*) *Spontaneous vegetables.*] A due attention to the circumſtances in which particular vegetables are ſpontaneouſly produced, leads directly to the ſure and ſucceſsful means of cultivating them by art. Linnæus juſtly obſerves (in a curious paper upon this ſubject in the firſt volume of the Swediſh Acts) that the directions given in many books of gardening are founded in empyriciſm or random practice; and that it is from wild plants alone that a rational method of culture can be deduced; that all plants grow ſomewhere wild, and that the buſineſs of art is to imitate their natural climate. By climate is underſtood the joint concurrence of earth, air, water, and heat.

The earths or ſoils in which vegetables grow, are far from being the ſimple bodies mentioned under that head in the foregoing part: they are compounded of all the kinds of mineral earths, and of that into which animal and vegetable ſubſtances themſelves are reſolved by putrefaction, blended together in various proportions. They may, nevertheleſs, be commodiouſly ranged, in regard to the preſent view, into four claſſes, according to the particular ingredient which prevails in the compoſition: (1.) Clayie, (2.) chalky, (3.) ſandy, including thoſe which abound either with ſand itſelf, or with ſuch other earthy or ſtony particles as do not in the leaſt imbibe or are affected by water; and (4.) black vegetable and animal mould. Each of theſe ſoils produces plants peculiar to itſelf, and which degenerate or periſh in others. It is on ſandy hills that the Fir and other reſinous trees attain to their vigour, and ſhed their Turpentines and Balſams: the *Galeopſes*, as the abovementioned author obſerves, are the natural growth of black earth, and die in ſand, whilſt *Ornithopus* flouriſhes in ſand, and periſhes in a black mould.

Under air may be included the viciſſitudes of ſolar light diffuſed throughout the atmoſphere; which light ſeems to affect vegetables independently of heat, and in a manner hitherto inexplicable. All plants grow weak and ſlender in the confined air of hot-houſes, and much

and

When mineral Salts abound in the ſoil, they are in part imbibed by the plant, and appear to be unſubduable by its digeſtive powers. Hence vegetables produced

and much more ſo if the ſolar light is excluded. Plants whoſe flowers are naturally the moſt odoriferous, if raiſed in a perfectly dark place with all the advantages of warmth, moiſture, *&c.* either do not flower at all, or bring forth flowers which have hardly any ſmell. The Jaſmine tree, whilſt it covers the outſide of a wall with its fragrant flowers, is not obſerved to produce a ſingle one upon ſuch branches as have forced their way within, even into a warm, an airy, and a light room. High hills in different parts of the world, the Lapland crags, the Alps, Olympus, and Ararat, bring forth ſimilar plants, many of which are never met with in lower grounds. Theſe plants grow extremely quick, nature making amends for their ſhortneſs of ſummer, by a continual agitation and renewal of air: they are ſmall, but loaded with innumerable ſeeds. Removed into gardens, they grow more ſlowly to a larger ſize, but abort, or produce little fruit.

River, ſtagnant, ſpring, and ſea-waters, and watery and dry ſoils, have each their peculiar plants: ſucculent plants rot from the quantity of water which many others require. It is obſervable, however, that land as well as aquatic vegetables may be raiſed and ſupported for a length of time, by placing the little roots, waſhed clean from earth, in water alone. It ſeems as if water and air, or the contents of waters and of the atmoſphere, were univerſally the immediate matter which affords aliment to vegetables; as if the earth ſerved only as a matrix for vegetables to keep them firm, and to preſerve moiſture about the roots; as if the difference of ſoils conſiſted wholly in their being more or leſs ſoft or compact, ſo as to be eaſily or difficultly penetrated by the tender roots, and in their more or leſs readily imbibing and effectually retaining water. Thus clay abſorbs water very ſlowly and difficultly, its particles expanding in proportion as they are moiſtened, ſo as to prevent the further progreſs of the liquor: if water be poured into a cavity made in a lump of dry clay, great part of it evaporates without being ſoaked in. Chalk on the other hand very quickly imbibes water, tranſmits it to every part of the maſs, and does not eaſily let it go; whilſt ſand ſuffers it to percolate inſtantaneouſly through the interſtices of the grains, without imbibing any into its ſubſtance.

With regard to heat, the plants of the torrid zone require, according to Linnæus, between the fiftieth and ſixtieth degree of Fahrenheit's thermometer; thoſe of the temperately warm, as the ſouthern parts of Europe, the Cape, Japan, China, between the thirtieth and fortieth; thoſe of the temparately cold, not above thirty-eight. Theſe ſeem to be nearly the mean degrees of heat of the reſpective climates. The plants of cold climates will not bear the heat of warm ones, any more than thoſe of the warm can ſupport the cold: ſome of the Cape plants in the heat of the torrid zone, grew at firſt amazingly, but ſoon after they loſt their leaves, and were difficultly kept alive. In this, however, there is a conſiderable latitude: plants may be raiſed in a climate not their own, provided the difference is not very great; by degrees they become as it were naturalized to it; if once they have produced ſeeds, theſe ſeeds are much leſs apt to miſcarry, and produce hardier plants than ſuch as are brought immediately from their native country. Tobacco, produced in nitrous grounds, or in ſuch as have been largely dunged, are often found to participate of Nitre; and thoſe on the ſea-coaſts, of marine Salt, though

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bacco, from ſeeds of our own growth, ripens a month ſooner than ſuch as is raiſed from foreign ſeeds.

It was by following nature, that the ingenious botaniſt above-mentioned has been ſo ſucceſsful in bringing up the vaſt variety of plants that have fallen under his care. The *rubus caule unifloro foliis ternatis* was ſome time ago, he tells us, thought incapable of being raiſed about Stockholm, till attention to its natural climate taught to keep it covered with ſnow during the winter and great part of the ſpring. Muſa, the moſt ſpecious plant in nature, had ſtood near an hundred years in the Dutch botanic garden, and could not be made to blow: on conſidering that its native country is Surinam, where the weather is dry for one half year and rainy next, it was kept long without water, and afterwards kept watered abundantly: it now flowered, and perfected its fruit; and by the ſame management another Muſa was made to flower the next year.

He obſerves, that we can eaſily imitate nature in regard to earth, water, and the degree of heat; and wiſhes we could equally imitate her in the renewals and agitations of air. This alſo it is in the power of art to effect. The principle, that warm air aſcends above cold, affords means of obtaining conſtant changes and ſucceſſions of air wherever there is warmth and cold.

Dr. Hales has applied this principle to the improvement of common hotbeds. If an aperture is made in the top of one end of the frame, and at the bottom of the other, and a deſcending pipe inſerted into this laſt, a ſtream of freſh air will paſs continually over the ſurface of the bed. This air may be warmed before its admiſſion, by carrying the pipe that conveys it through the hot dung.

What is here effected by the heat of dung, may be done in hot-houſes by that of fire. A pipe heated by the fire, and reaching to a conſiderable height in the houſe, will occaſion a continual circulation of the air in the houſe, that which is warmed in the pipe aſcending, whilſt the colder air at the bottom comes in to ſupply its place, and receiving warmth from the tube, aſcends in like manner, and this uninterruptedly whilſt the heat continues. If the lower part of the pipe is made to communicate with the external air, it will bring in freſh. If the fireplace opens, immediately or by a pipe, into the houſe, the colder part of the air at the bottom will paſs off through the fire (for fire requires a large quantity of air for its ſupport,) whilſt freſh air is brought in and warmed by the other pipe.

Stronger and more ſudden agitations of air, ſufficient to raiſe a moderate wind among the plants, may be obtained occaſionally by mechanic impulſe. I have made the outer and inner doors of the room, with a proper cavity between them, ſerve for a ventilator, the cheek which bounds the cavity on one ſide being made of a circular curvature, that the inner door, in its motion backwards and forwards, may fit cloſe to it all the way. The inner door is furniſhed with a valve at bottom, which on pulling the door backwards receives a part of the air of the houſe into the cavity, and with another at top, by which, on puſhing the door forwards, the air is forced out again with ſtrength enough to give a conſiderable ſhake to almoſt all the plants in a large hot-houſe. The outer door alſo is furniſhed with valves, through which, by a few reciprocations

VEGETABLES. though no marks of either of thoſe Salts can be diſcovered in other plants of the ſame ſpecies raiſed in different ſoils *(c)*. From inattention to this circumſtance, ſome of thoſe who called chemiſtry in aid for the examination of vegetables, have erroneouſly aſcribed to all the plants of one ſpecies, ſaline ingredients which had been caſually abſorbed by an individual.

and age. Plants differ likewiſe remarkably in their quality at different periods of their growth. Thus ſundry roots, which examined early in the ſpring, are found to be highly aromatic *(d)*, become leſs and leſs ſo in proportion

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reciprocations of the inner door, the external air is plentifully pumped in, or the internal air driven out, all the valves being made to open occaſionally outwards or inwards, and ſecured on either ſide with buttons.

(c) Vegetables imbibe Salts from the ſoil.] Henckel, in his *Flora ſaturnizans*, carries this point ſo far, as to ſuppoſe that plants growing about mines or in metallic countries, abſorb from the earth particles of the ſeveral metals whoſe ores are there to be met with, and that plants are ſometimes thus naturally impregnated with Silver and with Gold, as well as with the baſer metals, and with the poiſonous metallic body Arſenic. He mentions ſeveral fabulous ſtories in proof this opinion. There is not one well atteſted example of any metallic ſubſtance being diſcovered in vegetables, except Iron; of which a minute portion has been found in all the vegetable matters that have been examined with that view, whatever kind of ſoil they were produced in. See p. 111.

The ſame celebrated chemiſt imagines, that roots or ſeeds planted in earths that have been impregnated with colouring matters, will imbibe the colour, and tranſmit it unaltered to the flowers. This alſo is extremely queſtionable. If the ſtems indeed of ſundry white flowers, as the Lily, be placed in certain coloured liquors, as the red or purple juices of berries, ſo much of the juice is ſaid to ariſe in a few hours through the ſtem into the veſſels of the flower, as to variegate it with ſtreaks of its own colour. But when the plant is taken entire, and its roots ſet in the ſame coloured liquors, the flower receives from them no viſible tincture: the colouring matter in one caſe paſſing barely through the tubulous ſtem, whilſt in the other it paſſes through the whole vaſcular ſyſtem, and is changed and aſſimilated by the digeſtive powers of the plant.

(d) Roots, in ſpring.] The roots of plants have been generally ſuppoſed to be in their greateſt degree of perfection in the autumn, when the leaves begin to fall off: but this appears rarely, if ever, to be the caſe. Thus much ſeems univerſally to obtain, that when plants have run up to flower, the roots prove much weaker in ſmell and taſte, and their juices more crude and watery than before that period; that after flowering, the roots of annual and biennial plants continue to grow more and more effete till they periſh; and that thoſe of perennials do not recover their vigour till the enſuing ſpring: it is when the root is going

VEGETABLES.

portion as the leaves and ſtalks ariſe: the leaves in the mean time grow ſtronger and ſtronger, till the flowers are ready to burſt forth, and then begin to loſe of their fragrancy, as if the finer and more grateful parts were tranſmitted to the flowers and ſeeds. How different are the common culinary herbs at different ages; and fruits in their different ſtates of maturity.

NATIVE PRINCIPLES *of* VEGETABLES.

The native principles;

THE ſubſtances naturally contained in vegetables, and ſeparable from them by art, are, (1.) Gum, (2.) Reſin, (3.) a ſubtile Oil, (4.) Camphor, (5.) a groſs Oil, and (6.) a ſaline matter; together with (7.) Phlegm or Water, intimately blended with theſe, and which ſerves as a vehicle to dilute and fit them for circulation; and (8.) an earthy ſubſtance, which is the baſis of all vegetable bodies, the principle on which their firmneſs and ſolidity depends.

Gum,

GUMS are inſipid and inodorous ſubſtances, ſoluble in water into a viſcous or glutinous liquid, not acted upon by vinous ſpirits or by Oils (*e*), not volatile

in

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going to puſh forth its firſt leaves, that it is ſtrongeſt in medicinal as well as vegetative power. Whether biennial roots are moſt vigorous at the falling of the firſt year's leaves, or the ſhooting of the next, is not quite ſo clear.

The moſt perfect ſtate of the leaves of plants is ſaid to be juſt before the appearance of the flower. This rule is alſo very far from being general: perhaps it holds principally, if not ſolely, in the herbaceous plants, or thoſe which die to the ground in winter. The leaves of Mint, and ſundry other aromatic herbs, diſcover in the ſpring very little of the ſtrong flavour by which they are ſo eminently diſtinguiſhed in their more advanced ſtate; whilſt on the contrary, thoſe of the Sweet-briar, and ſome other odoriferous ſhrubs, loſe much, before they flower, of the fragrance which they had in the ſpring. The young buds or rudiments of the leaves of the black poplar tree have a ſtrong fragrant ſmell approaching to that of Storax, and yield, on a chemical analyſis, a reſinous extract not greatly different from that valuable exotic Reſin: by the time that the leaves have attained to their full growth, their fragrance is exhauſted. The fineſt Tea, according to the accounts of travellers, is the earlieſt leaves of the Shrub, gathered whilſt they are young; thoſe which ſucceed them, and the firſt ones when grown old, having leſs and leſs of the admired flavour.

(*e*) *Gums not acted upon by Oils.*] Though pure dry Gums are not miſcible with, or in the leaſt affected by Oils, yet when ſoftened with water into a mucilage or thick liquid, they unite eaſily by triture or

agitation,

NATIVE PRINCIPLES.

in the heat of boiling water, not fuſible or inflammable in the fire. They are commonly called *Mucilages* when ſoftened with water, or when conſidered as blended with the other principles of vegetables; and *Gums*, when ſeparated in a pure ſolid dry ſtate.

Reſins.

RESINS are ſoluble in vinous ſpirits and in Oils, not acted upon by water, not volatile in the heat of boiling water, fuſible in a ſmall degree of heat, and readily inflammable on the contact of any flaming or ignited body: of themſelves they have no ſmell; but they often retain, or have induſtriouſly preſerved in them a part of the odorous principle, and are nevertheleſs looked upon as pure Reſins. In their liquid ſtate they are called *Balſams*, and when combined with any conſiderable portion of Gum, *Gummy-reſins*.

Eſſential Oil,

The SUBTILE OILS are ſapid and odorous, ſoluble in Spirit of Wine, miſcible with the groſſer Oils, not miſcible with water, totally volatile in the heat of boiling water, very readily inflammable. It is in theſe, that the odours of almoſt all vegetables, and of many the taſtes, alſo reſide; whence they are called *Eſſential*. The Oil itſelf however is not the immediate principle of ſmell: it contains a far more ſubtile ſubſtance, of which the Oil is only the matrix, on which the ſmell wholly depends, and whoſe particular nature is wholly unknown. If an odorous Oil be expoſed for a length of time to the air, it will almoſt entirely loſe its ſmell without ſuffering any conſiderable diminution of its weight (*f*).

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agitation, with Oils both expreſſed and diſtilled, into a milky or butyraceous compound; which may be largely diluted with water, without any ſeparation of the Oil and Gum. From this property of Gum, we are enabled to mingle oily and reſinous bodies with watery liquors for medicinal uſe, more effectually than by any other means as yet diſcovered.

(*f*) *Odorous Oils loſe their odour in the air.*] Their ſmell is likewiſe in great meaſure imbibed by water: on agitating the Oil repeatedly with freſh parcels of water, nearly all its ſmell will be by degrees communicated to the aqueous fluid, without much loſs of the ſubſtance of the Oil. This ſubtile odoriferous principle is called by Boerhaave *Spiritus rector*, or the preſiding Spirit of plants.

NATIVE PRINCIPLES. Camphor.

CAMPHORS are ſolid concretes, ſoluble in vinous ſpirits, in Oils, and in mineral acids, particularly the nitrous, not acted upon by water, totally volatile in the heat of boiling water, eaſily fuſible, highly inflammable, ſubliming unchanged in cloſe veſſels, without leaving any fæces. Their ſolubility in Aqua fortis, and their totally ariſing not only in diſtillation with water, but when committed to the fire without any addition, readily diſtinguiſh them from Reſins and coagulated Oils, with which they have often been confounded. They have always a ſtrong pungent ſmell, reſembling that of the ſubject, and do not loſe their ſmell like eſſential Oils, but retain it ſo long as any of the Camphor itſelf remains unexhaled.

Expreſſed Oils,

The GROSS OILS are inſipid and inodorous, not miſcible with water or with vinous ſpirits, but readily with eſſential Oils, not volatile in the heat of boiling water, inflammable in the fire, Theſe are uſually extracted by expreſſion, and hence diſtinguiſhed by the name of *Expreſſed* or *Expreſſible Oils.*

Salt.

The native SALTS of vegetables have the general characters of ſaline bodies, taſte, and ſolubility in water: ſome diſſolve likewiſe in Spirit of Wine. They are of different kinds, ſweet, auſtere and acid; but never alcaline, all alcaline Salts being creatures of art.

Gums and Mucilages are found in greater or leſs quantity in all the vegetables that have been examined. The Oils and Salt are in many deficient, or in ſo ſmall proportion as not to be ſeparable from the other principles but by a deſtructive analyſis, by a degree of fire which deſtroys the texture of the plant, and all its native qualities. No eſſential Oil, and much leſs a Camphor, is to be expected from inodorous vegetables; and no conſiderable quantity of ſaline matter from any but thoſe which are manifeſtly very ſweet or very acid.

Juices naturally extravaſated.

Vegetables when arrived at perfect growth, are ſubject, like animals, to ſpontaneous ruptures of the veſſels, and an effuſion of their contents, and to more

NATIVE PRINCIPLES.

more profuſe diſcharges on being wounded. The various Gums, Reſins, Balſams and gummy Reſins, brought from abroad for medicinal or mechanic uſes, are the natural juices of herbs, ſhrubs and trees, exuding in the warmer climates, ſpontaneouſly or from inciſions. Many of theſe kinds of products may be collected alſo in our own country. Thus, the Cherry and the Plum-tree bleed in ſummer a glutinous fluid, which on the exhalation of its aqueous part, concretes into a ſolid Gum; and thus the Pine and the Fir ſhed their balſamic or oily and reſinous juices. Our Poppies bleed Opium from their heads; Angelica, Maſterwort, Lovage, *&c.* aromatic Gummy-reſins from their roots.

Extracted by art.

The active principles of vegetables are ſeparable more effectually and more perfectly by art, not only from the groſs earthy matter, but from admixtures of one another. As gummy and ſaline ſubſtances diſſolve in water, they may be extracted from all the plants that contain them, by infuſion in that menſtruum; and in like manner, eſſential Oils and Reſins are got out by vinous ſpirits: where oily and reſinous matters are in large proportion, they are ſometimes ſeparable from the ſubject by boiling it in water, the Oil or Reſin melting out by the heat, and ariſing to the ſurface, indiſſoluble in the aqueous liquor: eſſential Oils and Camphor, which exhale in the heat of boiling water, may be collected in the watery vapour, pure from all the other principles of the plant. By theſe operations, the native juices of all vegetables, the principles in which their ſmell, their taſte, their medicinal activity, and their colours (*g*) reſide,

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(*g*) *Colours.*] Though many vegetables give out their colours, along with their ſmells and taſtes, to watery or to ſpirituous menſtrua, or to both; there are not a few whoſe colour is extracted neither by one nor by the other, nor by a mixture of the two; the blue flowers of Cyanus for inſtance. And indeed of the greater part of vegetable colours it is hard to ſay whether they depend upon a reſinous or a gummy matter, or on ſome diſtinct principle.

Water impregnated with certain ſaline ſubſtances extracts the colouring matter of ſundry vegetables more effectually than pure water could do;

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reſide, are obtained unaltered: the plant ſtill preſerves its original form and ſtructure, though robbed of all its peculiar qualities.

I. GUMS *and* RESINS.

GUMS and RESINS.

WHEN Reſins or eſſential Oils are intimately blended with gummy and ſaline matter, as they generally are in vegetables, a part of the Reſin or Oil will diſſolve in water along with the Gum, and a part of the Gum will diſſolve in Spirit of Wine along with the Reſin. Hence ſpirituous tinctures made from plants are not purely reſinous, but contain a part of their mucilage, whilſt watery infuſions participate of the Reſin and Oil, and conſequently of the taſte, ſmell, and medicinal virtue, reſiding in thoſe principles. There is ſcarcely any vegetable, however reſinous, that does not give out ſome part of its virtue to water.

Tinctures and infuſions.

Pure reſinous tinctures.

If plants be infuſed or boiled in water till that menſtruum has extracted all it is capable of doing, and afterwards digeſted in Spirit of Wine, the ſpiri-

do: a ſubſequent addition of certain other Salts renders it incapable of keeping in diſſolution thoſe particles which it had before taken up, and which of courſe muſt now ſettle by degrees to the bottom. Thus, if to a yellow decoction of Turmeric or a red one of madder roots, made in a watery ſolution of fixed alcaline Salt, we add a proper quantity of ſolution of Alum; the yellow particles of the one and the red of the other will ſeparate and ſubſide, and leave the liquor clear. At the ſame time, the acid of the Alum being abſorbed by the alcaline Salt, the aluminous earth falls down with the colouring matter, and dilutes and brightens the colour. Theſe kinds of preparations are commonly called *Lakes*.

On what principle the tinging matter is here precipitated is not known. It ſeems as if the tinging particles themſelves had ſuffered an alteration from the action of the two Salts; for though the liquor remaining after the precipitation (which is no other than a ſolution of vitriolated Tartar) gains no colour from the Lake, it extracts a ſufficiently deep tincture on digeſting it with a freſh parcel of the ſubject which the Lake was made from.

Solution of Alum precipitates likewiſe many vegetable colours that have been extracted by water alone; and in this caſe alſo, a part of the earth of the Alum falls down along with the colouring particles. On what foundation this happens we do not know. The whole affair requires a more thorough examination than has hitherto been beſtowed upon it.

GUMS and RESINS.

tuous tincture thus obtained, will be merely reſinous: theſe kinds of tinctures made from odoriferous or aromatic vegetables, have generally little flavour of the ſubject, the more ſubtile part of the Reſin, or eſſential Oil, being either previouſly diſſolved by the water along with the gummy or ſaline matter, or diſſipated during the boiling. —— In like manner, if Spirit of Wine be applied at firſt, it will diſſolve the Reſin and the Oil, and leave undiſſolved a part of the Gum or Mucilage, which may now be extracted by water, pure from any other principle, perfectly inſipid and inodorous.

Pure gummy infuſions.

General obſervations.

The watery extractions from vegetables are named *infuſions* or *decoctions*, according as they are prepared by macerating or infuſing, or by boiling the plant in the water: the ſpirituous are named *tinctures*, *eſſences*, or *elixirs*, according as they have a leſs or greater degree of conſiſtence, or are leſs or more loaded with the ſoluble parts of the ſubject; when as thick as the native balſams or reſinous juices, they are called *ſpirituous balſams*. The method of making theſe preparations is too familiar to require any explanation in a wotk of this kind: what ſubſtances are adapted to one or the other treatment, will appear from the examination of particular bodies in the following ſections. We ſhall here only obſerve in general, that though vinous ſpirits extract the odorous part of vegetables far more perfectly than water, yet the ſpirituous tincture diſcovers frequently leſs ſmell than the watery infuſion, the ſpirit ſeeming to cover or conceal the ſmell; that both water and ſpirit diſſolve moſt readily the finer and more grateful parts of plants; that heat promotes the action of both menſtrua, and enables them more ſpeedily to take up along with thoſe, the groſſer and more ungrateful matter. If Sena, for inſtance, be infuſed in cold, or for a little time in warm water, the liquor will purge far more mildly than an infuſion made in hot water for a longer time, though both infuſions be reduced to the ſame degree of ſtrength, in regard to the quantity of matter diſſolved in them, by a ſuitable evaporation of the fluid.

Gums and Reſins.

Watery and ſpirituous extracts.

By totally exhaling the fluid, the gummy or reſinous matter which it had taken up from the plant, is obtained in a ſolid form: theſe preparations are called, not Gums and Reſins, as not being purely ſuch, but *watery* and *ſpirituous* or *gummy* and *reſinous extracts.* An extract made by water, from a plant that has previouſly undergone the action of ſpirit, may properly be called Gum or Mucilage; and one made by ſpirit, after water has performed its office, may be looked upon as a pure Reſin. A pure Reſin may be procured alſo be evaporating a tincture made in ſpirit at firſt, till it begins to grow thick, and then adding a quantity of water: the Reſin, indiſſoluble in that menſtruum, will ſeparate and fall to the bottom, whilſt the gummy parts before mixed with it, remain ſuſpended in the water.

In the making of extracts, it is particularly neceſſary to perform the evaporation with a gentle heat: in many caſes, the liquor may at firſt be kept boiling for a time over an open fire, but as ſoon as the matter begins to grow a little thick, it muſt be removed into a gentler heat, otherwiſe it will ſcarce be poſſible to prevent its burning to the veſſel, and contracting a diſagreeable empyreumatic ſmell and taſte; it is now to be placed in a water-bath, or rather poured into ſhallow flat veſſels, and exſiccated in a warm room.

Draſtic vegetables rendered mild.

In the making of extracts for medicinal uſe, from draſtic vegetables, ſtrong boiling is oftentimes of advantage, as it abates the violence of the medicine, and renders its operation more mild and ſafe. For this purpoſe, the infuſion or decoction of the ſubject ſhould be made with a large quantity of water, that the liquor may be kept the longer boiling before it grows thick: the inſpiſſated matter may likewiſe be diſſolved afreſh, and the coction and inſpiſſation repeated. By this treatment, great alterations are made in vegetables, independently of the diſſipation of their volatile parts. Aſarum, a ſtrong emetic, GUMS and RESINS.

with a large quantity of water, yields an extract which proves merely purgative: if this be diſſolved afreſh, and again inſpiſſated, it loſes its purgative, and acquires a diuretic virtue: by a third inſpiſſation, it is changed from a diuretic to a ſudorific. In like manner, the violent emetic power of the white Hellebore, and the cathartic of the black, are mitigated or deſtroyed by long coction: tobacco from a virulent emetic and cathartic, becomes a ſafe pectoral, attenuant and anodyne. The milder purgatives alſo, as Sena and Rhubarb, are proportionably weakened by a like treatment (*h*).

II. ESSENTIAL OILS.

ESSENTIAL OILS.

WHEN odorous vegetables are boiled in water for any conſiderable time, their ſmell is loſt both from the plant and from the decoction, the volatile Oil, in which the odour reſides, being diſſipated along with the ſteam of the boiling liquor. If the vapour which exhales, be caught and condenſed in proper veſſels, as the common ſtill, the Oil ſeparates from the diſtilled water, and ariſes to the ſurface or ſinks to the bottom according to its gravity. Where the quantity of Oil is very ſmall, it is moſt commodiouſly taken off with a little Cotton: where the quantity is large, it is parted from the water by means of ſpout-receivers and ſeparating glaſſes contrived for this uſe.

Subjects.

Theſe oils are obtainable only from odoriferous vegetables, but not equally from all of that claſs, nor proportionably to their degree of fragrance. The Violet, the Lily, the Narciſſus, the Hyacinth, and ſome other flowers of a delightful ſmell, even the damaſk Roſe itſelf, ſcarcely yield a drop of Oil, unleſs

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(*h*) *Draſtic vegetables corrected.*] The virulence of draſtic vegetables is undoubtedly deſtroyed or abated by long continued boiling; but that by this proceſs they acquire the excellent diuretic, pectoral, aperient and other virtues aſcribed to them by ſome of the chemiſts, is not quite ſo certain. Whatever may be in this, the preparations are by no means fit for general uſe, as it is impoſſible to adjuſt them to any ſtandard in point of ſtrength.

leſs ſome hundred weights are committed to the operation at once: from ſuch quantities I have ſeen, in Italy, a little Oil obtained from them all.

ESSENTIAL OILS.

Analogy with Reſins.

Eſſential Oils may be conſidered as little other than ſubtile liquid Reſins or Balſams. By digeſtion or heat they actually change into thick Balſams, and at length into perfect, ſolid, brittle Reſins: diſtilled again in this ſtate, they ſtill yield, like moſt of the natural Reſins, a portion of fluid Oil, the groſſer reſinous matter remaining in the ſtill. By certain treatments, and by the admixture of concentrated mineral acids (*i*), a like change is producible in theſe Oils inſtantaneouſly.

In moſt of the herbs, flowers, ſeeds, barks, or roots, that yield an eſſential Oil, the microſcope diſcovers ſhining reſinous particles: if theſe be carefully picked out and ſeparated, the remaining matter will no longer yield a ſingle drop of Oil. All herbs and trees, in proportion as they are the more reſinous, yield the more Oil: the Larch, the Pine, and the Fir, which abound with Reſin, abound alſo with Oil, whilſt the Birch, the Beech, and the Oak, are as deficient in one as in the other. The Turpentine and Fir-tree yield the moſt Oil of any vegetable ſubſtance known: hence the Oils of theſe are employed for the ſophiſtication of the more rare and coſtly. Next follows Savin, which affords an ounce and an half upon ſixteen ounces. Cloves, Nutmegs, &c. give the next largeſt quantity: after theſe come Mint, Marjoram, Spike, Saſſafras, &c. all which yield a conſiderable proportion. The Oil of Juniper-berries is ſold very cheap, but we muſt not

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(*i*) *Eſſential Oils with acids.*] Theſe Oils unite difficultly with alcaline Salts, but very readily with the concentrated mineral acids: with theſe laſt they form a thick butyraceous or ſolid concrete, which when freed from the redundant acid by ablution with water, proves in many reſpects ſimilar to Reſins: it has a reſinous taſte, liquefies in a ſmall heat, and totally diſſolves in rectified Spirit of Wine. A great heat and ebullition, with a diſcharge of noxious fumes, commonly enſue upon mixing the Acid and the Oil: by a haſty addition of the concentrated nitrous ſpirit, moſt Oils may be actually ſet on fire. See page 237.

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not conclude from hence that theſe berries afford any very large quantity, much the greateſt part of it being common Oil of Turpentine: only about ſix ounces of Oil were obtained from ſixteen pounds of the berries (*k*).

Their ſeat.

Eſſential Oils reſide chiefly in the rinds, fine leaves, flowers and ſeeds of plants, and commonly in particular cells diſtributed through thoſe parts. In freſh vegetables, the Oil is blended with watery moiſture: and hence when recent plants are committed to diſtillation, very little Oil is obtained in a ſeparate ſtate. Dry plants yield more Oil, but here again there is another inconvenience, the more ſubtile, volatile and fragrant parts exhaling in the exſiccation along with the aqueous humidity. Moſt eſſential Oils, however, are uſually diſtilled from dry plants: the exſiccation ſhould be performed with care, not in the ſun, much leſs by fire, but in a moderately warm ſhady place (*l*).

Differences according as the ſubject is uſed freſh or dry.

Of the difference betwixt the Oils obtained from recent and dry vegetables, we have a notable inſtance in Citron-peels. Let the freſh peel be diſtilled in the heat of a water-bath without addition, and the dry peel with water in the common manner: compare the two Oils together, and they will be found extremely different; the firſt highly ſubtile, volatile, penetrating, and truly ethereal; the latter far groſſer, of a thicker conſiſtence, not near ſo agreeable in ſmell or taſte, approaching more to the nature of Reſins or Balſams, the conſiſtence of which laſt it acquires ſpontaneouſly upon keeping for a few years. The ſame thing holds alſo, though not in an equal degree, in all odoriferous vegetables: even from freſh ones we obtain two kinds of eſſential Oil, one groſſer, and the other more ſubtile.

In

(*k*) *Quantity of Oil.*] An account of the quantity of Oil obtained from different ſubſtances, may be ſeen in the *Practical Chemiſtry*, page 390.

(*l*) *Exſiccation of plants for eſſential Oil.*] Plants are rarely dried with us, in order to increaſe the yield of their eſſential Oil.

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Method of obtaining them.

In the diſtillation of eſſential Oils, regard muſt be had to their degree of volatility or ponderoſity; ſome requiring for their elevation a conſiderable fire, which would be injurious to others, by diſſipating or altering their more ſubtile parts. A few, as thoſe of Citron-peel, and ſome tender leaves and flowers, may be commodiouſly drawn in a water-bath without any addition (*m*); but much the greater number require the ſubject to be boiled in water over a naked fire. The water ſerves here both as a menſtruum to diſſolve and diſunite the gummy and mucilaginous parts, in which the oily ones were entangled, and as a vehicle to carry up the Oil; as alſo, to ſecure the plant from burning to the veſſel. The quantity of water may be about three or four times as great as that of the ſubject to be diſtilled.

Uſe of ſaline additions.

Compact ſubſtances are to be previouſly macerated in the water for three or four days, that the Oil may be the more effectually extricated. To every ten quarts of water may be added two or three handfuls of common Salt: this not only promotes the action of the water, and prevents the fermentation or putrefaction, which vegetables infuſions are liable of themſelves to run into, but likewiſe increaſes the weight of the fluid, renders it capable of bearing a greater heat, and thus enables it to elevate more readily the groſſer and more ſluggiſh Oils (*n*).

(*m*) *Diſtillation of Oils in a water-bath.*] The eſſential Oils of many odoriferous plants are eaſily obtained in the higheſt degree of perfection, by diſtilling them with the vapour of water kept ſomewhat below boiling. The Oil of Lavender flowers, of Roſemary tops in bloom, thus diſtilled, are quite colourleſs, very light, in appearance almoſt like pure Spirit of Wine, exquiſitely retaining the native odour of the flowers, without any of that ſtrong diſagreeable ſcent perceived in thoſe obtained by violent coction of the plant in large quantities of water. The common ſtill is eaſily adapted to this purpoſe, by fixing a hair-cloth immediately over the ſurface of the water, and placing the herb upon it, ſo as to ariſe quite into the head.

(*n*) *Salt renders the water ſuſceptible of greater heat.*] In this intention, the addition of Salt may poſſibly be of ſome uſe; but what ſervice it is capable of doing during the maceration does not appear. In that part of the operation, it ſhould ſeem to be rather injurious, as it tends to harden inſtead of ſoftening the ſubject, and to impede inſtead of promoting the action of the water. There is no occaſion for any other

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Some employ for theſe purpoſes other ſaline additions, as regenerated Sea-ſalt, the Sal digeſtivum, Glauber's Sal mirabile, mineral acid ſpirits, crude Tartar, and fixed alcaline Salts. The two laſt are by no means to be commended: Tartar, as containing itſelf a groſs oily matter, and being very difficult of ſolution, can at beſt do little ſervice; and alcalies, though they powerfully promote the reſolution of the ſubject, yet at the ſame time entangle and detain the Oil, forming with it a ſaponaceous concrete. With regard to acids, Homberg relates, that from Fennel ſeeds and Roſes a much larger quantity of Oil was obtained when Spirit of Salt or Oil of Vitriol were added, than when the ſubjects were macerated for an equal length of time without thoſe additions. But if the Oil thus obtained was really in greater quantity it was ſurely inferior in quality: theſe acids alter the quality of all diſtilled Oils, and diſpoſe them to a reſinous conſiſtence.

By inciſion

Some vegetable matters, particularly the rinds of Citrons, Lemons, Oranges, yield a part of their eſſential Oil upon bare inciſion. By this ſimple proceſs, an Oil is prepared from Citron-peel, in Italy, more ſubtile and volatile than that obtained by diſtillation. The fruit is rolled upon a plate ſtuck full of ſharp points; by which many thouſands of punctures are made at once in the rind, and the oily cells laid open: the oil which thus exudes, is received in a veſſel placed underneath, and what ſtill remains in the peel is afterwards extracted by diſtillation. Hoffmann relates, that the Italian Oil of Citron-peel, or *Oleum de cedro*, is ſo light as to ſwim upon Spirit of Wine,

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other addition than plain water: the moſt compact woods, duly raſped or ſhaved, will be ſufficiently penetrated by maceration in water, and the ſubſequent diſtillation with a boiling heat, to give over all the eſſential Oil they contain. With regard to the preventing of putrefaction, it ſhould ſeem, that in proportion as the Salt prevents that proceſs, it prevents the effect expected from the maceration; the opening, as it is called, or reſolution of the ſubject here required, being no other than the early ſtage of a general proceſs, which, in its advanced ſtate, is termed putrefaction.

Wine; but I have always obſerved it to fall to the bottom: probably he made the experiment with a phlegmatic ſpirit.

Differences of the Oils of different vegetables.

The eſſential Oils obtained from different vegetables, differ from one another, not only in ſmell and taſte like the vegetables themſelves, but in ſundry other reſpects: Some are ſo heavy as to ſink in water; ſuch as thoſe of the Indian aromatics, Cinnamon, Cloves, Saſſafras, *&c.* Others, and indeed the greater number, ſwim on water (*o*). The Oils of Lavender, Balm, Roſemary, Savin, if carefully diſtilled,

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(*o*) *Gravity of Oils.*] As there are conſiderable differences in the gravity of the Oils of certain vegetables, ſome have thought to diſtinguiſh, upon this principle, the genuine Oils from the ſophiſticated, or the Oil of one ſubſtance from that of another. A further examination ſhews, that the gravity can be no certain teſt; that one and the ſame ſubject yields, at the beginning and end of the diſtillation, Oils more different in gravity than thoſe obtained from different ſubjects. How nearly ſome eſſential Oils, that are very diſſimilar in their other qualities, approach in ſpecific gravity, and how nearly the groſs expreſſed Oils approach to ſome of the eſſential, will appear from the following table. The proportional weight of rain-water, as in other tables of this kind, is 1,000.

Eſſential Oil	of Saſſafras	1,094
	of Cinnamon	1,035
	of Cloves	1,034
	of Fennel	,997
	of Dill	,994
	of Penny-royal	,978
	of Cummin	,975
	of Mint	,975
	of Nutmegs	,948
	of Tanſy	,946
	of Caraway Seeds	,940
	of Origanum	,940
	of Spike	,936
	of Roſemary	,934
	of Juniper-berries	,911
	of Oranges	,888
	of Turpentine	,792
Expreſſed Oil	of Linſeed	,932
	of Olives	,913
	of Rapeſeed	,913

Theſe are the gravities of the particular ſpecimens examined; and of moſt of them we ſhall ſeldom perhaps meet with another ſpecimen, that does not differ as much from the ſame Oil in the table, as that in the table does from the Oil next to it.

tilled, prove limpid and colourleſs, whilſt that of Spike is greeniſh yellow; of Thyme and Savoury, browniſh; of Wormwood, brown or greeniſh black; of common Camomile, blue; of Milfoil, ſometimes blue and ſometimes green; of Cloves, Cinnamon, Saſſafras, at firſt colourleſs, changing by age to a yellowiſh, and at length to a reddiſh-brown colour. Thoſe of Aniſeeds and Rue congeal and become conſiſtent in cold weather, whilſt moſt of the others preſerve their fluidity.

How to be kept.

Eſſential Oils, as being fraught with a very volatile odoriferous principle, ſhould be carefully preſerved from the air. They are beſt kept in glaſs bottles fitted with ground glaſs ſtoppers, not in a warm, but in a cool and dry place. Warmth promotes not only the diſſipation of their ſubtile fragrant part, but likewiſe their diſpoſition to become reſinous.

Their adulterations detected.

The dearer eſſential Oils are frequently adulterated with Oil of Turpentine, expreſſed Oils, Spirit of Wine, &c.——An admixture of Spirit may be diſcovered, by pouring a little of the ſuſpected Oil into water: if the water grows milky, and the quantity of Oil viſibly leſs, we may be ſure that this adulteration has been practiſed: if no milkineſs appears, we may be ſatisfied that the Oil has no mixture of ſpirit.——Expreſſed Oils are diſcovered by adding a quantity of ſpirit which will diſſolve the eſſential, and leave the expreſſed behind.——Oil of Turpentine is diſtinguiſhed by moiſtening a bit of cloth with the mixed Oil, and ſetting it in a gentle warmth: the ſmell of genuine Oil will ſoon be diſſipated, that of Turpentine remaining. The Oil of Turpentine is apt likewiſe to diſſolve the Oil painting on the bottles in which theſe kinds of preparations are uſually kept in the ſhops (*p*).

Though

(*p*) *Adulteration of eſſential Oils.*] As all eſſential Oils agree in the general properties of ſolubility in Spirit of Wine, indiſſolubility in water, miſcibility with water by the mediation of Mucilages, Sugar, or yolk of eggs, volatility in the heat of boiling water, &c. it is plain they

Though all eſſential Oils diſtil freely along with boiling water, there are many which cannot be elevated by the heat that boiling water communicates through the ſides of another veſſel. If Oils already ſeparated from the ſubject be committed to diſtillation by themſelves, there are few that will begin to ariſe, till the heat has become ſtrong enough to alter or deſtroy their peculiar flavour, and give them a burnt ſmell and taſte. It is obſervable, that the moſt ſubtile and volatile eſſential Oils require a conſiderably ſtronger heat to make them boil than water does (*q*).

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Their habitude to fire in different circumſtances

they may be variouſly mixed with one another, or the dearer ſophiſticated with the cheaper, without any poſſibility of diſcovering the abuſe by any trials of this kind.

And indeed, it would be of little advantage to the purchaſer, if he had infallible criteria of the genuineneſs of every individual Oil. It is of as much importance that they be *good* as that they be *genuine*; for I have often ſeen genuine Oils, from incurious diſtillation, and long and careleſs keeping, weaker both in ſmell and taſte than the common ſophiſticated ones.

The ſmell and taſte ſeem to be the only certain teſts that the nature of the thing will admit of. If a bark has, in every reſpect, the appearance of good Cinnamon, and is proved indiſputably to be the genuine bark of the Cinnamon-tree, yet if it wants the Cinnamon flavour, or has it but in a low degree, we reject it; and the caſe is the ſame with the Oil. It is only from uſe and habit, or compariſon with ſpecimens of known quality, that we can judge of the goodneſs either of the Drugs themſelves or their Oils.

Moſt of the eſſential Oils, indeed, are too hot and pungent to be taſted with ſafety, and the ſmell of the ſubject ſo much concentrated in them, that a ſmall variation in this reſpect is not eaſily diſtinguiſhed; but we can readily dilute them to any aſſignable degree. A drop of the Oil may be diſſolved in Spirit of Wine, or received on a bit of Sugar and diſſolved by that intermedium in water: the quantity of liquor which it thus impregnates with its flavour, or the degree of flavour which it communicates to a certain determinate quantity, will be the meaſure of the degree of goodneſs of the Oil.

(*q*) *Habitude of Oils to fire.*] Many Oils, in their firſt diſtillation from the ſubject, carry up with them a portion of groſs reſinous matter; which, if too ſtrong a heat has been uſed in the operation, proves ſometimes very conſiderable. On more carefully diſtilling them with water a ſecond time, the Reſin remains behind, and is generally found to be inſipid and inodorous: the Oil by this means becomes more limpid and pure, and at the ſame Time is in good meaſure freed from any ungrateful empyreumatic taint which it might before have received from the fire. In this rectification of Oils, whether debaſed in the diſtillation itſelf, or by age, ſome have employed common Salt, Sal mirabile, and other additions, which do not appear upon experiment to be of any advantage.

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WATER agitated with eſſential Oils, imbibes a portion of that ſubtile principle on which the odour depends, ſo as to become notably impregnated with their flavour. Hence the water, which diſtils along with the Oil, participates always of the ſmell of the plant, and of its taſte alſo, where the taſte depends upon the oily principle. The diſtilled waters of ſome ſubſtances, as Cinnamon, Cloves, Cardamoms, Aniſeeds, Fennel-ſeeds, *&c.* poſſeſs the diſtinguiſhing taſte as well as the ſmell of the ſubjects; whilſt thoſe of Roſes, Wormwood, and many others, have nothing but the ſmell; the bitterneſs of Wormwood, the aſtringency of the Red roſe, and the purgative quality of the damaſk, reſiding in a fixed matter, incapable of ariſing in diſtillation.

Subjects for diſtilled Waters.

Water receives a ſtrong impregnation by this proceſs, not only from thoſe odorous vegetables which abound with Oil, but likewiſe from the more tender flowers which yield no actual Oil unleſs immenſe quantities are committed to diſtillation at once, as the Jaſmine and the Lily. Vegetables in general, poſſeſſed of any conſiderable ſmell, flavour, aromatic warmth or pungency, give over thoſe qualities to Water in diſtillation; whilſt bitterneſs, ſweetneſs, aſtringent, purgative, emetic, unctuous, mucilaginous virtues remain behind in the ſtill. How ridiculous is it to diſtil Waters, as many diſpenſatories ſtill direct, from ſubſtances of this laſt claſs, which give over nothing of their virtues.

General obſervations.

Waters diſtilled from one ingredient are called *ſimple*; from more than one, *compound.* Freſh juicy vegetables are ſometimes diſtilled by the heat of a water-bath, without any additional liquid; that heat being inſufficient to burn or ſcorch the plants, whilſt it

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Eſſential Oils, diſtilled in a retort without water, firſt give over a thin fluid Oil, ſlightly empyreumatic, a thicker one remaining in the bottom. If this be further urged, greateſt part of it ariſes, only a little coaly matter being left; but the ſpecific flavour of the ſubject is deſtroyed, and the diſtilled Oil has only a burnt ſmell and taſte, like that of the empyreumatic ones to be treated of hereafter.

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it elevates great part of their flavour along with their native moiſture *(r)*. The method of performing the diſtillation is too commonly known to require any

(r) Diſtillation in a water-bath.] It has been commonly ſuppoſed that a heat much leſs than that of a water-bath is ſufficient to elevate the fragrant parts of vegetables: that all thoſe plants, which diffuſe their active effluvia through the open air, will give out the ſame effluvia, when included in cloſe veſſels, and expoſed to a heat no greater than that which obtains in the atmoſphere in ſummer.

“ Take, ſays a celebrated chemiſt, Roſemary freſh gathered, in its
“ perfection, with the morning dew upon it, and lay it lightly and un-
“ bruiſed upon the broad round plate within our little cylindrical fur-
“ nace . . . . Then cover the furnace with its large conical ſtill-head,
“ and apply a glaſs receiver to the noſe thereof. In the fire-place of
“ the furnace put a lighted coal, that does not ſmoke, and raiſe up an
“ equable degree of heat, not exceeding eighty-five degrees on Fahren-
“ heit's thermometer; and let this heat be kept up ſo long as any li-
“ quor comes over . . . . This Water contains the elementary Water
“ and preſiding Spirit of the plant, a ſpirit ſmall in bulk but rich in
“ virtue, and exhibiting the ſpecific ſmell and taſte, and particular
“ virtue of the ſubject; leaving the remainder exhauſted . . . . Hence
“ we may underſtand that the various, peculiar, and often ſurprizing
“ virtues of plants, may be widely diffuſed through the air, *&c.*”*

I have ſubmitted to this proceſs Roſemary and other aromatic herbs, without the promiſed ſucceſs: the diſtilled liquors in general had hardly any thing of the fine flavour of the ſubject: even when the heat of a boiling water-bath was made uſe of, there were very few plants that gave over to the diſtilled liquor any conſiderable ſmell or taſte. It is by the aſſiſtance of the free ventilation in the open air, that the ſun's heat robs odoriferous plants of their fragrancy; and even when thus aſſiſted, it leaves their other active virtues unhurt: theſe alſo the humid air of the mornings and evenings diſſolves and imbibes.

Hence the different effects upon animal bodies, of the natural effluvia or aerial infuſions of certain vegetables, from thoſe of their diſtilled Waters. Damaſk roſes, in drying, impregnate the air of the room with their laxative virtue; and Red-roſe buds in like manner give out their aſtringency; virtues which never ariſe in diſtillation, but which common water and ſpirit extract readily by infuſion. The author above-quoted mentions ſome examples of this kind, without ſeeming to have duly attended to their conſequences: for if the ſhade of the Walnut-tree makes the body coſtive, and the effluvia of Poppies procure ſleep; as theſe virtues are incapable of being elevated in diſtillation, does it not follow, that they muſt be communicated to the air upon ſome other principle?

With regard to the uſe of a water-bath, though there are few vegetables that give over their flavour in that degree of heat, yet for thoſe that do, it is undoubtedly of great advantage: fire ſenſibly injures, in proportion to its degree, the flavour of aromatic herbs, and thoſe which are moſt volatile ſuffer the moſt from it. Some tender flowers, as thoſe of Roſemary, have their fragrance impaired, by the bare mechanic action of watery or ſpirituous liquors, independently of heat, nearly in the ſame manner as it is by bruiſing them.

In

* *Boerh.* proceſs i. *Sh.* tranſlat.

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any particular illuſtration. But it may be proper to obſerve, that as leſs of the oil ſeparates in the diſtillation of freſh than of dry vegetables, the Waters obtained from the former are proportionably ſtronger than thoſe from the latter: that the more compact kinds of vegetables require to be cut or bruiſed, and macerated or digeſted for ſome time in the Water previouſly to the diſtillation, in the ſame manner as for eſſential oils, with this difference however, that the common Salt, there made uſe of, is here leſs proper, a part of its acid ariſing with the Water: it has been cuſtomary to ſalt roſes for diſtillation, in order to preſerve them, without drying, till a ſufficient quantity could be collected: the Water diſtilled from ſuch roſes has often been found to retain ſo much of the acid of the Salt, as to turn milky with ſolution of Silver or Lead, and to corrode Iron. Some ſubſtances are advantageouſly fermented for a few days, with the addition of a little Sugar and Yeaſt, their ſmell and virtue being by this means more effectually extricated

In diſtilling theſe kinds of ſubjects, I have varied the proceſs, by applying, inſtead of Water or ſpirit in their groſs form, only their vapours: the liquor being poured into a ſtill, a hair-cloth ſtretched on an iron-hoop, is let in above it, and on this the freſh unbruiſed flowers are lightly ſpread: the vapour into which the liquor is reſolved by the heat of a Water-bath, paſſing gently through the flowers, imbibes their fragrance unimpaired, and condenſes into a water or ſpirit greatly ſuperior to thoſe prepared in the common manner.

The foregoing obſervations point out a method of improving alſo the preparation of extracts. If infuſions of Mint, Balm, and ſundry other vegetables of the aromatic kind, be diſtilled by a gentle warmth in cloſe veſſels, little more than the watery menſtruum will ariſe, greateſt part of the flavour of the ſubject remaining behind in the extract. When the diſtillation is performed by a boiling heat, the whole of the flavour comes over with the Water; and when the inſpiſſation is performed in open veſſels, however gently, it is almoſt wholly abſorbed and carried off by the air. Our author himſelf ſeems to have been ſenſible of this in his experiments on tea; for, in order to procure an extract from tea, poſſeſſing the admired flavour of the leaf, he finds it particularly neceſſary to inſpiſſate the infuſion without communication with the open air.

Thus we ſee, that by diſtilling many odoriferous vegetables in cloſe veſſels, we may obtain their fragrancy either in the Water that diſtills, or retain it in good meaſure in the extract, according as the degree of heat made uſe of is ſtrong or gentle; and that, by evaporating them in open veſſels, their fragrancy is in either caſe carried off by the air.

extricated and communicated to the diſtilled liquor: Veronica, a plant of very little ſmell, and which, if immediately committed to diſtillation gives over nothing conſiderable, yields, if ſlightly fermented, a Water that ſmells and taſtes ſtrongly of the herb. The quantity of Water made uſe of muſt be proportioned to the nature of the ſubject: whatever quantity is added, the diſtillation muſt be continued no longer than while the liquor proves ſufficiently impregnated with the flavour of the ingredients. The virtues of many plants come over moſt plentifully in the firſt runnings; whilſt thoſe of others are more ſtrongly locked up, and ſcarce begin to ariſe till the diſtillation has been continued for ſome time. Where the plant is of ſuch a kind as to give but a weak impregnation to the diſtilled Water; we may render the liquor ſtronger by cohobation, that is, by drawing it over again from a freſh parcel of the ſubject (*s*).

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SPIRIT

(*s*) *Waters made ſtronger by cohobation.*] This is another of the many proceſſes in which I have, on trial, been greatly diſappointed. Though ſome of the chemiſts affirm, that diſtilled Waters in general may be rendered, by repeated cohobations, of any aſſignable degree of ſtrength, and their virtues exalted without limitation†; I have not found that repetitions of theſe operations make any conſiderable addition to the ſtrength even of thoſe Waters, whoſe exaltation by this treatment has been particularly ſpecified.

The diſtilled Waters of Mint, Roſemary, and other aromatic herbs, being rediſtilled a number of times ſucceſſively from freſh parcels of the reſpective ſubjects; inſtead of being more and more exalted and improved, they were on every repetition more and more debaſed. Some of them indeed, by one cohobation, did ſeem to be rather mended, and ſometimes a ſecond hid hardly any injury: but after this period, they all received an ungrateful taint from the repeated action of the fire, without gaining any more of the flavour of the ſubject than they had at firſt.

It is not by diſtillation, but by infuſion, that Water can be unlimitedly impregnated with any of the principles of plants. Water extracts by infuſion the gummy parts of vegetables; and it is a property of all gummy ſubſtances to diſſolve indefinitely in Water, that is, to unite with any proportion of it, ſmall or large, and render the liquor thicker and thicker as the quantity of gummy matter is increaſed. When Reſins or eſſential Oils are intimately combined with gums, as they are in moſt vegetables, theſe compounds unite alſo indefinitely with Water.

Hence

† *Id.* proceſs xvi.

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Diſtilled ſpirits.

SPIRIT of Wine, conſidered as a vehicle for the volatile virtues of vegetables, has one advantage above Water; keeping the whole of the eſſential oil, that ariſes with it, diſſolved. Thus, if Citron-peel be diſtilled with rectified ſpirit, the oil will come over diſſolved in the menſtruum into an uniform tranſparent liquor, poſſeſſing, in a high degree, the fine flavour of the peel: on diluting this ſpirit with Water, the mixture immediately becomes milky, the oil ſeparates, and is gradually collected upon the ſurface. This is an uſeful method of obtaining ſome of the more volatile oils.

Spirit of Wine cannot be made to receive ſo great a degree of heat as Water: it boils and diſtils much ſooner, and no increaſe of fire will make either of them hotter after they have begun to boil. Hence the oils obtained in the above method by means of ſpirit, prove more fragrant, as having undergone leſs

Hence by macerating or infuſing, in the ſame Water, freſh parcels of aromatic herbs, the liquor takes up more and more of their ſoluble parts, till it grows too thick to be poured off, and the loſs of fluidity is the only bounds to the impregnation.

In diſtillation, on the other hand, nothing ariſes with the water but the eſſential Oil; and from the pure eſſential Oils this fluid extracts only a limited quantity. Salts are in this reſpect ſomewhat analagous to Oils: when a certain quantity of Salt is diſſolved in Water, the liquor, though thin and fluid as at firſt, will take up no more: by the application of heat, it may be made to diſſolve a larger quantity than in the cold, but all that is ſo diſſolved will be ſeparated and thrown out again upon an abatement of the heat. So, when eſſential Oils are coagitated with Water by a boiling heat, and elevated along with it in form of vapour; the Water, condenſing again, keeps a part of the Oil diſſolved, and throws out the reſt. The Water is now ſaturated, and it is in vain to endeavour, by any repetitions of the diſtillation, to make it imbibe more.

Hence the uſe of employing the Water that ariſes in the diſtillation of eſſential Oils, for ſubſequent diſtillations of the Oil of the ſame ſubject: being ſaturated with Oil in the firſt diſtillation, it diſſolves none of that which ariſes with it in the others; and thus the produce of Oil proves proportionably larger than if freſh Water was taken.

It follows from this account, that there is one caſe, in which cohobation may be of ſome ſervice; that when the Water is not fully ſaturated in the firſt diſtillation, it may be made to imbibe more by a repetition of it. But ſurely it is more adviſable, to uſe the plant, in ſuch quantity as may give a ſufficient impregnation at once, than to endanger debaſing the flavour which the liquor has once received by communicating more.

leſs heat, than thoſe diſtilled with Water. But hence alſo there are many oils which this liquor is incapable of elevating: for though they are all volatile in the heat of boiling Water, there are few which ariſe in the heat of boiling ſpirit.

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The greater number of odorous vegetables give over nothing conſiderable to ſpirit. If rectified Spirit of Wine be diſtilled over from Rhodium wood, Cinnamon, Nutmegs, and even from ſome of the more fragrant flowers, as roſes and lillies, it will ſcarcely diſcover any ſmell or taſte of the ſubjects; whilſt Water brings over the whole of their flavour. The only method of obtaining a Spirit impregnated with the volatile Oils of theſe kinds of ſubſtances is, to diſſolve ſome of the Oil itſelf in pure Spirit of Wine, or to uſe in the diſtillation a mixture of Spirit and Water.

III. CAMPHORS.

CAMPH.

CAMPHORS are extracted by diſtillation with Water, nearly in the ſame manner as eſſential oils. From ſome vegetables, the Camphor ariſes at firſt in its proper ſolid form: from others, only a fluid oil diſtils, from which the Camphor concretes upon long ſtanding. It is chiefly from plants produced in the warmer climates, that Camphors are obtainable; as the tree called, from its abounding with this concrete, *Arbor camphorifera*, the roots of the Cinnamon-tree, Zedoary, Schœnanthus, Cardamon-ſeeds, the Oriental mint, Abrotanum, Milfoil, Daiſy, Juniper, Roſemary, Sage, Camphorata, Lavender, Hyſſop, Clary, Maudlin, Marjoram, *&c.* though I have likewiſe extracted a true Camphor from the common European thyme.

IV. EXPRESSED OILS.

Expres. Oils.

Method of obtaining them.

GROSS Oil abounds chiefly in unctuous ſeeds and the kernels of fruits, as Linſeed, Rape-ſeed, Poppy-ſeeds, Almonds, Nuts, Peach-kernels, *&c.* Theſe or other like ſubſtances, in order to the extraction of their expreſſible Oil, are pounded or ground in mills into a ſmooth maſs, then incloſed in a canvas bag, and committed to a ſtrong preſs, by which the Oil is plentifully forced out, amounting ſometimes to above half the weight of the ſubject. Some previouſly warm the plates of the preſs, and even heat the pounded maſs itſelf in a kettle, keeping it conſtantly ſtirring with a wooden ſpatula, to prevent its burning. This facilitates the ſeparation of the Oil, and if the heat is ſmall, does it no injury: in winter or if the ſubject is moiſt, a gentle warmth is particularly neceſſary, in one caſe to render the Oil fluid, in the other to diſſipate the humidity. Some have been accuſtomed both to warm and to moiſten the maſs, and thus procure a ſomewhat larger yield of Oil: this practice is nevertheleſs highly to be blamed, as the Oil thus obtained, quickly ſpoils and becomes rancid.

Differences from one another.

All the expreſſed Oils agree in their general qualities, whatever ſubſtance they were drawn from. There are however ſome particular differences conſiderable enough to deſerve notice: thus the workmen find that ſome of theſe Oils, as that of Linſeed, anſwer better for varniſhes than the purer and finer ones of Olives or Almonds. Moſt of theſe Oils, however carefully drawn, become rancid and acrimonious upon long keeping; but there are ſome, particularly the Oil of Ben-nuts, which continue unaltered for ſeveral years: hence the uſe of this Oil as the baſis of perfumes. Moſt of them coagulate in winter into a thick, white, butyraceous maſs; but ſome, as thoſe of Linſeed and Rape-ſeed, remain fluid. They are all leſs readily inflammable than eſſential

Oils, and conſume more ſlowly: a pound of Oil Olive, for inſtance, continues burning as long as four or five pounds of Oil of Turpentine.

Seat of expreſſible and eſſential Oils in ſeeds.

Some ſubſtances contain both an expreſſible and eſſential Oil, as the ſeeds of umbelliferous plants; thoſe of Aniſe for inſtance. In this caſe, the Oil obtained by expreſſion generally brings forth with it a part of the eſſential Oil, and thus proves impregnated with the flavour of the ſeeds: the Oils expreſſed from other vegetable matters have no particular taſte or ſmell: the expreſſed Oil of the acrimonious Muſtard-ſeed is perfectly void of acrimony. In what parts of thoſe ſeeds the two Oils reſide, was little known or examined, till the younger Geoffroy of Paris, in diſtilling ſome Coriander-ſeeds, having employed, perhaps accidentally, almoſt mere huſks, diſcovered the true ſeat of the eſſential Oil: experiments on other ſeeds alſo, of that claſs, have evinced, that the eſſential reſides ſolely and wholly in the outer ſkin, and the expreſſible Oil in the kernel of the ſeed. This obſervation is not however to be extended beyond the ſeeds of umbelliferous plants: of Cardamom-ſeeds, it is the kernel that contains the eſſential Oil and the medicinal activity.

V. ESSENTIAL SALTS.

ESSENTIAL OILS.

Method of preparing them.

ESSENTIAL or native Salts, ſo called in diſtinction from the fixed alcaline Salts produced from vegetables by art, are obtained chiefly from plants of the acid kind, as Sorrel. A quantity of the leaves is gathered in the ſpring, pounded in a ſtone mortar with a wooden peſtle, and the juice preſſed out into tinned veſſels: ſome warm water may be added to the remaining maſs, and the expreſſion repeated, that the ſaline matter may be more perfectly extracted. The liquor ſuffered to ſtand for a day two, depoſites a thick feculence: being then poured off clear, and paſſed through a ſtrainer, it is ſet to evaporate in a cut glaſs body placed in a gentle ſand

ESSENTIAL SALTS.

ſand heat till about one half is waſted, or till it is reduced nearly to the conſiſtence of a ſyrup; after which it is removed into a cellar, and ſuffered to ſtand till the Salt has cryſtallized. Some continue the inſpiſſation further, put the matter into flat earthen diſhes, and pour ſome Oil on the ſurface. Others expedite the cryſtallization, by ſetting the liquor, duly depurated and evoporated, not in a cold cellar, but in a warm room, where it is left to ſhoot in the ſame manner as Sugar Candy. The cryſtals are to be nimbly rinſed with water, and dried upon ſpongy paper in a gentle warmth. Several of the cryſtals generally prove browniſh coloured and foul: if required to be pure and white, they are diſſolved in water, the ſolution filtered, and ſet to ſhoot a ſecond time. The ſaline matter remaining after the cryſtallization may be diluted with the water in which the cryſtals were waſhed, and after due purification, ſet to cryſtallize again as at firſt.

This tedious proceſs is rarely performed; and the nature of the Salts, obtainable by it from different vegetables, has been little examined. The Salts of acid plants are ſimilar in moſt reſpects to Tartar, though not as ſome have ſuppoſed, perfectly the ſame: the Salt of Sorrel is manifeſtly more acid, and diſſolves in half the quantity of water that Tartar requires. With regard to the preparation of them, much depends upon the liquor being duly purified from the groſs oily matter, which impedes the ſeparation and concretion of the Salt. The ſweet eſſential Salt of the Sugar Cane cannot be procured in its concrete ſaline ſtate, without the addition of Lime-water during the inſpiſſation, to promote its ſeparation from the unctuous matter (*s*).

It

(*s*) *Eſſential Salts.*] Stahl obſerves that the tedioufneſs of the cryſtallization is in great meaſure owing to the viſcid oily matter of the juice, which entangles and prevents the coaleſcence of the ſaline particles: hence he endeavours to improve the proceſs, by firſt extracting the oily and reſinous matter by Spirit of Wine, and afterwards the ſaline by water. He directs Wormwood, Brook-lime, Pellitory, Herb-

ESSENTIAL SALTS. Juices.

It may be proper to obſerve, that though juicy ſaline vegetables, whether of the acid or ſweet kind, give out their ſaline matter uninjured upon expreſſion; yet there are many, particularly aromatic herbs and flowers, whoſe juices retain nothing of their peculiar ſmell or taſte, and whoſe flavour is abſolutely deſtroyed by the action of the preſs. Squeeze betwixt the fingers a Violet or a Jaſmin flower, and all their fragrance is in an inſtant loſt.

THUS

Herb-mercury, Sope-wort, or other plants of the like kind, to be dried quickly in a ſhady place, then cut ſmall and digeſted in freſh parcels of rectified ſpirit, till the menſtruum ceaſes to extract any colour. The plant thus freed from its Oil and Reſin, is to be gently exſiccated and boiled in water, the decoction filtered, evaporated to a due conſiſtence, and ſet by in a cool place to cryſtallize. The cryſtals, he ſays, are found upon examination to be of the nitrous kind.

Spieſſius on the other hand (in the ſecond continuation of the *Miſcellanea Berolinenſia* ſeeks for the eſſential Salt in the ſpirituous tincture. Wormwood, Carduus benedictus, or other like plants, gently dried in the ſhade, are digeſted in Spirit of Wine, with a ſoft heat, till the liquor is tinged green, the tincture put into a glaſs cucurbit, and diſtilled with the heat of a water-bath, till ſo much of the ſpirit is come over, that the reſiduum may be of the conſiſtence of honey. The whole being now ſuffered to remain unmoved till grown perfectly cold, he finds beautiful pyramidal cryſtals ſhot from the ſides of the cucurbit towards its center.

The laſt mentioned author relates likewiſe that having made an eſſence (that is a ſaturated tincture) of Elecampane roots with Spirit of Wine, and kept it unmoved for a year, he found a great number of cryſtals ſhot from the bottom upwards of the thickneſs of a quill, and and about an inch long. He ſays the cryſtals obtained by this method are of the nitrous kind, but of a more ſubtile taſte than common Nitre, impreſſing only an agreeable coolneſs upon the tongue.

The two foregoing proceſſes agree but ill with one another: how far they are adequate to the purpoſes intended by them cannot be determined without further experiments. It is certain that Spirit of Wine diſſolves the ſubtile Oils and the Reſins of vegetables, which prove a great impediment to the cryſtallization of Salts: whence it ſhould ſeem, that the Salt might be afterwards extracted by water from the reſiduum, to much better advantage than from the plant at firſt. But it is certain alſo, that this menſtruum diſſolves many of the native vegetable Salts themſelves; and that if the tincture is ſaturated, or duly evaporated, the Salt ſeparates, leaving the oily and reſinous matter diſſolved. Thus Manna diſſolves totally in rectified ſpirit, and however foul before, is recovered white as ſnow, its impurities being left in the the menſtruum: thus tinctures of Celeri, Beet-roots, and other plants of the ſweet kind, made in rectified Spirit of Wine, depoſite on ſtanding a Saccharine Salt; the ſpirit, though it diſſolves the ſaline part by the aſſiſtance of heat, gradually parting with it in the cold, whilſt the other matter it had extracted remains diſſolved.

PRINCIPLES.

Native principles illuſtrated.

THUS we have ſeen, that the medicinal and other intrinſic powers of vegetables reſide in a few inſtances, which chemiſtry, by the moſt obvious and ſimple of her operations, extracts, ſeparates, purifies, and preſerves, unaltered in their quality, but greatly increaſed in activity by the rejection of the parts which are unactive: that ſome of theſe ſubſtances, as thoſe in which bitterneſs and aſtringency conſiſt, are diſſolved by boiling water, and left, upon evaporating the liquid, concentrated into an extract, whilſt that matter on the other hand, in which odours are lodged, exhales along with the water, and may often be collected in the form of an extremely active Oil: that hence, when bitter plants, for inſtance, are accompanied with an ill ſmell, we can procure in the extract, the ſimple bitterneſs diveſted of that offenſive part; and that in like manner, when fragrant ſubſtances are accompanied with a bitter nauſeous taſte, we procure the ſimple fragrance concentrated in the Oil: that by rectified Spirit of Wine, we frequently obtain the entire virtue of the plant, both fixed and volatile, combined into one extract.

Theſe ſubſtances we call the native principles of vegetables: *Native*, becauſe they naturally exiſt in in the ſubject, art doing nothing more than barely to extract them: *Principles*, not as being ſimple bodies, for they are all compounded; but as it is by theſe that one plant differs from another, and that every plant exerts its ſpecific powers; and as we cannot further reſolve them, without totally deſtroying their peculiar qualities, and converting them into ſubſtances, as different from any thing that exiſted in the original vegetable, as they are from one another.

Artificial principles.

Vegetables diſtilled in cloſe veſſels by a ſtrong fire, yield an acid or an alcaline liquor or both, and an acrimonious, fetid, empyreumatic Oil: in the bottom of the retort remains a black coal, which burnt in the open air changes into white aſhes: from theſe is obtained, by elixation with water, a portion of fixed alcaline Salt; a few vegetables excepted, which inſtead of a fixed alcali in the aſhes, afford a volatile one in the diſtillation.

PRINCIPLES.

Theſe products have no reſemblance in taſte, ſmell, or any other ſenſible property, to the original ſubject: nor are the Spirits, the Oils, the fixed or the volatile Salts produced from one vegetable, to be diſtinguiſhed from thoſe which are afforded by another. Yet ſuch has been the infatuation of the chemiſts, that in examining particular plants, they have hitherto fondly purſued this deſtructive reſolution, and aſſigned, for the natural principles of the plant, theſe artificial products which had no exiſtence in it.

We ſhall now proceed to examine vegetables ſingly, according to the ſyſtem of native principles here laid down, chuſing from the almoſt endleſs variety of ſubjects, which the vegetable kingdom affords, ſome of the principal that have been employed for medicinal, dietetic, or mechanic uſes. Theſe may be ranged in two general diviſions; the juices, which iſſue ſpontaneouſly, or are extracted or purified by the aſſiſtance of art; and plants or their parts in ſubſtance.

END OF THE FIRST VOLUME.

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